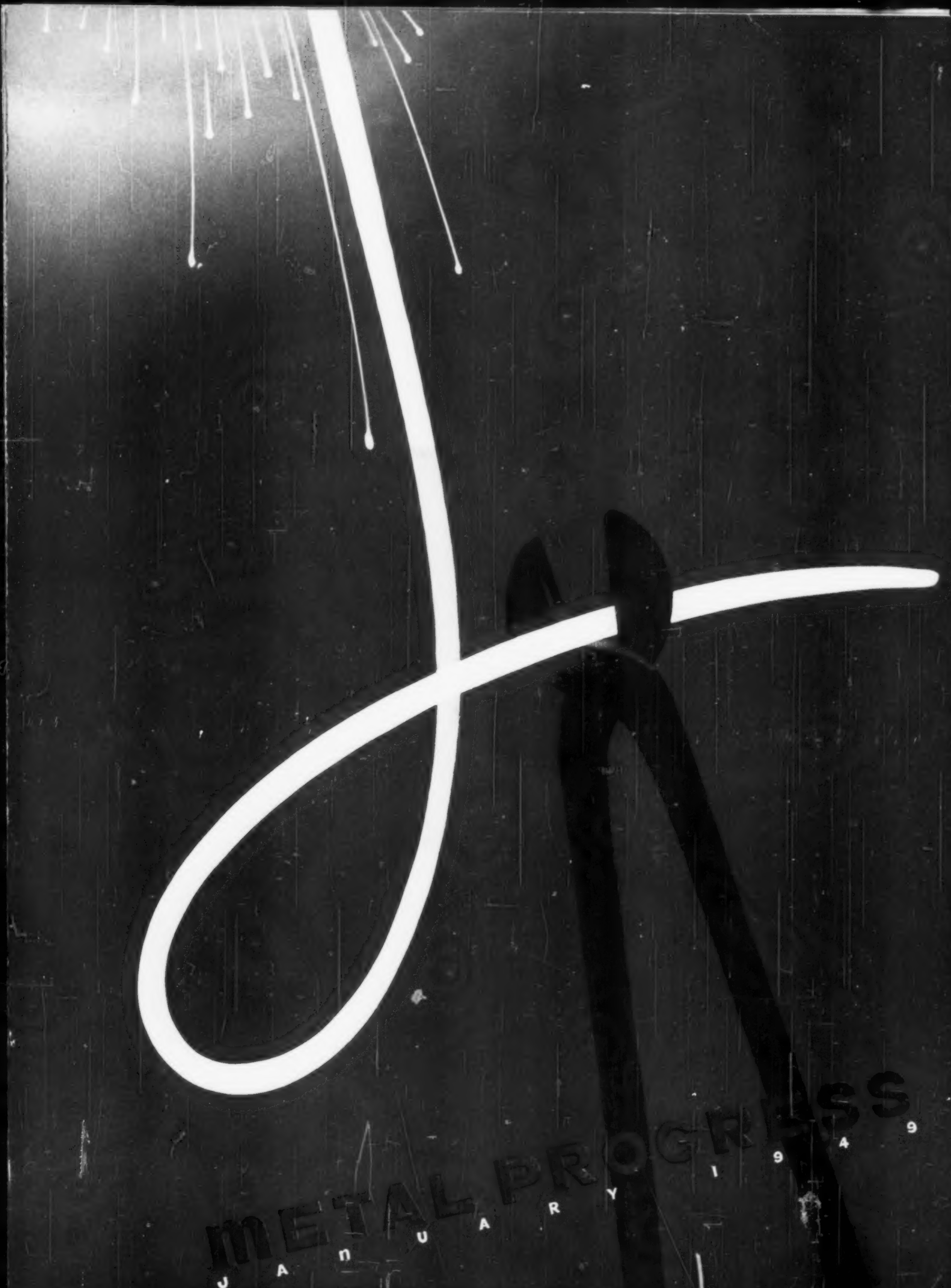
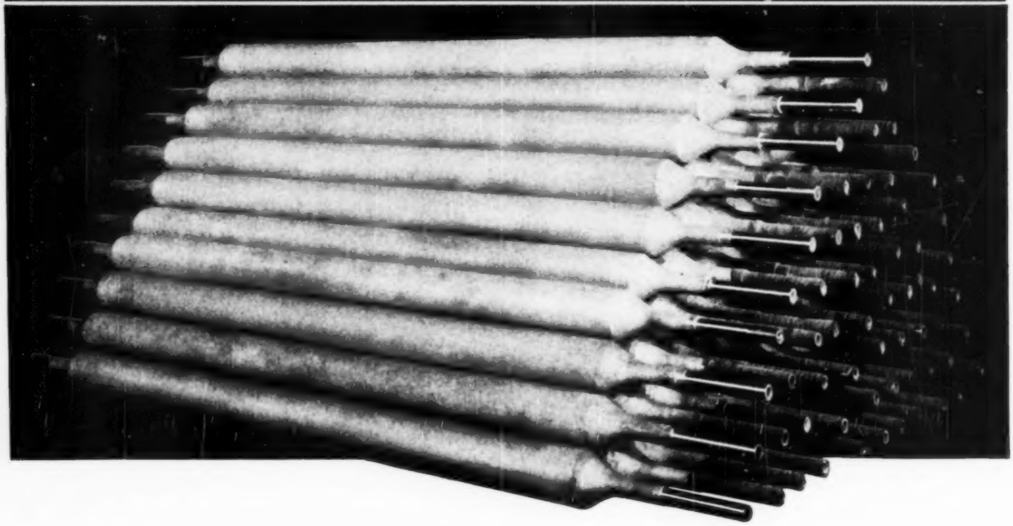

METAL PROGRESS
JANUARY 1949

MISCO *Centricast* Conveyor Rolls

for Bright Annealing • Normalizing • Heat Treating Furnaces

LIGHT · SOUND · STRONG · ACCURATE



THROUGH the application of our flash welding process to roll construction, mechanical joints have been eliminated in the manufacture of Misco Centricast Conveyor Rolls. No added metal is used at the joints because the end castings and the centrifugally cast mid-section are directly united under pressure at fusing temperature. Misco flash welded joints produce a sound one-piece construction. Misco Centricast Conveyor Rolls can be supplied in many sizes, with smooth cast, rough turned or bright ground finish. Thousands of Misco Centricast Conveyor Rolls are giving dependable service at temperatures up to 2050° F. Misco Centricast Conveyor Rolls will serve you better.

ALLOY CASTING DIVISION

Michigan Steel Casting Company

MISCO
Heat and Corrosion Resistant Alloys

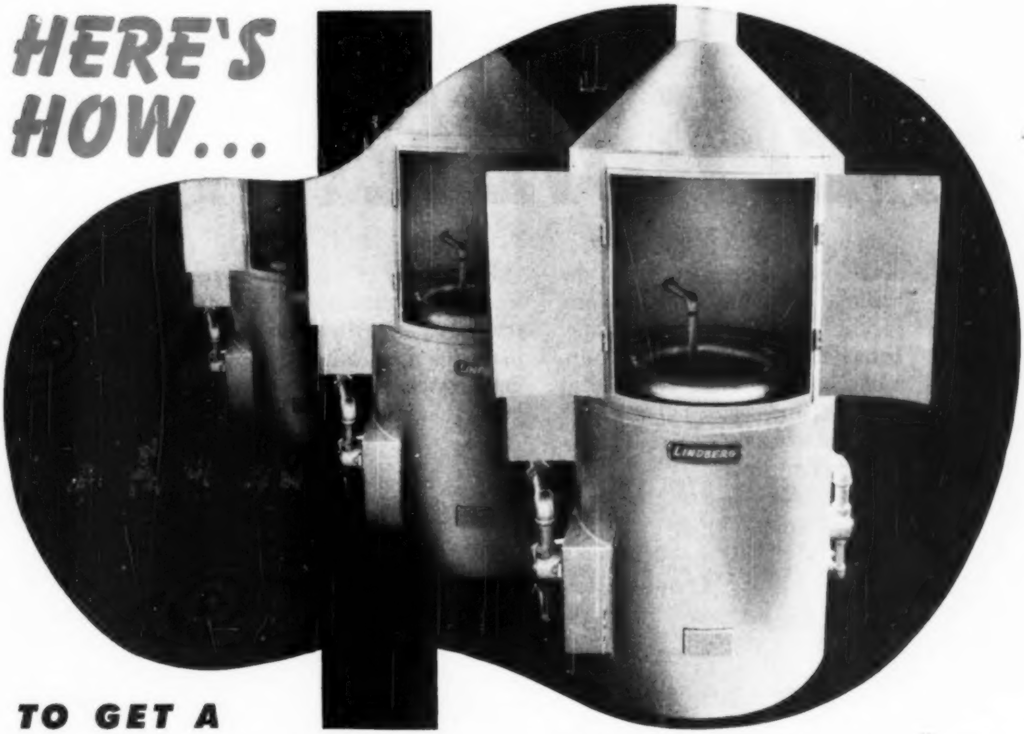
One of the World's Pioneer Producers and Distributors of Heat and Corrosion Resisting Alloys

1998 GUOIN STREET · DETROIT 7, MICHIGAN

Metal Progress is published and copyrighted, 1949, by American Society for Metals, 7301 Euclid Avenue, Cleveland, Ohio. Issued monthly; subscriptions $7.50 a year. Entered as second-class matter Feb. 7, 1921, at the post office at Cleveland, Ohio, under the act of March 3, 1879.

the PRODUCTS of TOMORROW
are in the
RESEARCH LABORATORIES TODAY
FOR HIGH TEMPERATURE COLOR TESTING
AS IMPORTANT AS GOOD DESIGN
"SPEED NITRIDING" in HEVI DUTY FURNACES
FOR RESIN RESEARCH AND ANALYSIS
TO IMPROVE METALS...
IT IS SIGNIFICANT THAT THE
OUTSTANDING MANUFACTURERS
OF THE COUNTRY USE
HEVI DUTY FURNACES
IN
RESEARCH and PRODUCTION
Send for Descriptive Bulletins
HEVI DUTY ELECTRIC COMPANY
HEAT TREATING FURNACES HEVI DUTY ELECTRIC EXCLUSIVELY
DRY TYPE TRANSFORMERS — CONSTANT CURRENT REGULATORS
MILWAUKEE 1, WISCONSIN

HERE'S HOW...



TO GET A

1 YEAR GUARANTEE

ON YOUR CYANIDE POTS

To introduce this unusual furnace we are offering to give you an unqualified guarantee for one year covering "Hi-Life" pots used with cyanide or lead (neutral salts excluded), under automatic temperature control.

The first Lindberg "Hi-life" Pot Furnace was put in operation two years ago. With 15,000 hours of operation behind it, the original pot is still going strong. Others put into operation later have passed the 8,000 hour mark. We don't ask you to believe in miracles! So we're backing the performance records of these pots with a one year guarantee.

In addition to pot life two to three times the best previous figures, you also get much faster heating and greater efficiency. The new Lindberg "Hi-life" Pot Furnace is lined with Silicon Carbide and Mullite refractories assuring low maintenance in the furnace itself.

Use the new Lindberg "Hi-Life" pots with the new Lindberg "Hi-Life" gas-fired Pot Furnace.

The Lindberg Engineering Company considers this new development one of the most significant improvements in furnace equipment in the past decade.

"Hi-Life" Pot Furnaces are available in these 4 standard sizes. (Note small overall dimensions)

POT SIZE		OVERALL SIZE	
24" Dia.	21" Deep	39½" Dia.	35½" Deep
20"	21"	35½"	35½"
16"	18"	31½"	32¾"
12"	18"	27½"	32¾"

LINDBERG ENGINEERING COMPANY 2448 W. Hubbard Street, Chicago 12, Illinois

LINDBERG FURNACES

The Case of the Happy Family

There is no happier family of electrodes than McKay Pluralloys—for these electrodes, developed in close cooperation with various steel companies, make possible the economical and efficient welding of hardenable, low-alloy, high-tensile steels.

McKay Pluralloy Electrodes are used successfully on such difficult-to-weld steels as high-carbon steel; low-alloy, hardenable, high-tensile steels; free machining, high-sulphur steels; cold-rolled steel; and abrasion resisting steels. The low spatter, freedom from slag interference, arc stability and smooth bead contours make them invaluable on the production line. The high tensile strength, freedom from porosity and the high ductility of the weld-metal recommend McKay Pluralloys to design engineers for the more difficult and exacting services.

All-position Pluralloy Electrodes cover a wide range of tensile strengths; the weld metal they deposit is free from "fish eyes," is of excellent metallurgical quality and has exceptionally good ductility. The following table shows the minimum "as-welded" tensile strength of each McKay Pluralloy Grade.

McKay Grade	Ultimate Strength	Yield Strength	Elong. in 2"
Pluralloy—70	74,775 psi	64,000 psi	31.0%
Pluralloy—90	94,375 psi	81,600 psi	26.0%
Pluralloy—100	104,200 psi	95,100 psi	23.0%
Pluralloy—110	111,725 psi	99,475 psi	21.5%
Pluralloy—3½% Ni	85,215 psi	73,975 psi	24.0%

★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★ ★

Want to Know More About

McKAY PLURALLOY ELECTRODES

Full information on the use of McKay Pluralloy Electrodes for welding hardenable, low-alloy, high-tensile steels is available without obligation. Write today for application data and testing samples.

THE McKAY COMPANY
403 McKAY BUILDING
Pittsburgh, Pa.
Sales Offices: York, Pa.

McKAY STAINLESS STEEL · MILD STEEL · ALLOY STEEL · WELDING ELECTRODES

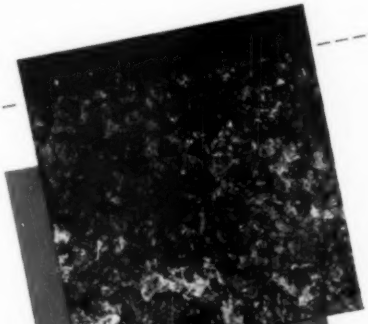
Researched, Developed and Manufactured to fill Industry's Requirements for Dependable Electrodes


WE WOULD LIKE TO POINT OUT
underfilm corrosion
just Can't happen
with
Weirzin
ELECTROLYTIC ZINC-COATED SHEETS AND STRIP
Paints, enamels, lacquers, varnishes and lithographic inks adhere to bonderized Weirzin securely and permanently, because underfilm corrosion cannot occur. The tight, malleable zinc coating, electrolytically applied, becomes an integral part of the sheet or strip... remains intact under all conditions of temperature and humidity . . . provides a perfect "tooth" for spray, dip or roller applications.
Extensive fabrication does not weaken this bond—after deep-drawing, forming and punching, the zinc coating remains unruptured and evenly deposited. There are appreciable savings in manufacturing, too, because Weirzin sheets and coils require no pickling or buffing, and very little cleaning . . . there is no need for a primer under paint.
WEIRTON STEEL CO.
WEIRTON STEEL COMPANY
WEIRTON, W. VA., Sales Offices in Principal Cities
Division of NATIONAL STEEL CORPORATION, Executive Offices, Pittsburgh, Pennsylvania
NATIONAL STEEL

NEUTRAL HARDENING

means just what it says . . .

No Scale No Decarb



Photomicrograph showing absence of scale or decarburization in a section of S.A.E. 1095 Steel (X100) hardened at 1500° F. in a neutral salt bath and quenched in oil. [illegible]

Automotive spline shafts being heated in a neutral salt bath equipped with a screw-conveyor mechanism. Temperature of the work is held within 5° F. even in this relatively large bath — 6 ft. long, 2 ft. wide and 2 ft. deep [illegible]

. . . and an amazing volume of work can be treated in small, relatively inexpensive salt bath equipment.

A neutral salt bath provides an ideal means of heating carbon or alloy steel parts without any deleterious effect on the surface, such as scaling, pitting, carburizing or decarburizing. The bath completely seals out all air while work is heating . . . and a thin film of salt remains when work is removed, protecting it right up to the instant of quenching.

All "protective atmospheres," gas generating equipment and specially trained operators required for their use are eliminated . . . with corresponding savings in initial expense, operating costs and floor space requirements.

Heating cycles are 4 to 6 times faster than in atmosphere or radiant type furnaces—enabling small furnaces to handle a large volume of work—because heat is transferred by conduction rather than by convection or radiation, all surfaces of the work being in direct physical contact with the molten salt. Heating, therefore, is both rapid and uniform . . . eliminating the cause of most distortion.

Unique internal heating principle of the AJAX furnace—utilizing patented, closely-spaced, immersed electrodes—produces an automatic electrodynamic stirring action within the bath which contributes to faster heating of the work and assures a temperature variation of less than 5° F. throughout the bath.

This internal heating feature also permits use of long-lived ceramic pots, avoiding contamination of neutral baths by metallic oxides produced by metal pots.

The advantages of hardening in a neutral salt bath can be further enhanced by use of an isothermal salt bath quench (martempering or austempering) to hold distortion to a minimum and eliminate quench cracking.

For more information on AJAX Electric Salt Bath Furnaces and their many uses — hardening, annealing, brazing, tempering, cleaning, quenching, etc. — metallurgists and metalworking executives are invited to write on their firm's letterhead for the new 72-page Booklet No. 116.

AJAX ELECTRIC COMPANY, INC.

910 Frankford Avenue • Philadelphia 23, Pa.

The World's Largest Manufacturer of Electric Heat Treating Furnaces Exclusively!

Associate Companies: **Ajax Metal Co.** **Ajax Engineering Corp.** **Ajax Electric Furnace Corp.** **Ajax Electrothermic Corp.**

In Canada: Canadian General Electric Co., Ltd., Toronto, Ont.

SELF-HEATING • SELF-CIRCULATING

AJAX

HULTGREN

ELECTRIC SALT BATH FURNACES

High Temperature Lubrication... 400° F. and up!

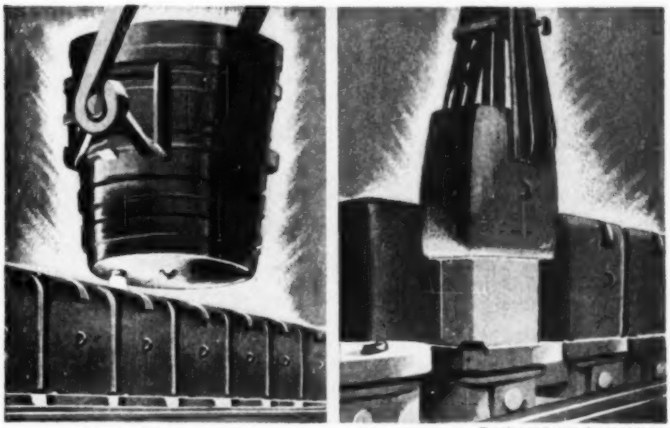
A large Midwestern steel company reports that easily applied "Darmold" Mold Wash—produced with **"dag"** colloidal graphite by the Dacar Chemical Products Company, Pittsburgh—has simplified ingot stripping...lengthened mold life...improved surface quality of ingots...reduced ingot product conditioning costs.

In the steel industry, as in countless other industries, **"dag"** colloidal graphite dispersions are continually conquering problems of high temperature lubrication. Perhaps one of the many **"dag"** colloidal graphite dispersions is the answer to your particular problem.

In addition to high temperature lubrication **"dag"** colloidal graphite dispersions are ideal for use in opaquing, parting, impregnating, general lubrication, and electronics work.

Consult Acheson Colloids engineers for possible money-saving applications of these versatile products in your business. Clip the coupon and mail NOW.

Acheson Colloids Corporation, Port Huron, Michigan; Boston; New York; Philadelphia; Pittsburgh; Cleveland; Detroit; Chicago; St. Louis; Los Angeles; San Francisco; Toronto.



Pouring and stripping steel ingot.

dag
REG U S PAT OFF
COLLOIDS

Send us information on "dag" colloidal graphite dispersions for:

- Extreme (high or low) temperature lubrication ☐
- General lubrication ☐
- Parting ☐
- Impregnating ☐
- Opaquing ☐
- Electronic applications ☐

J210

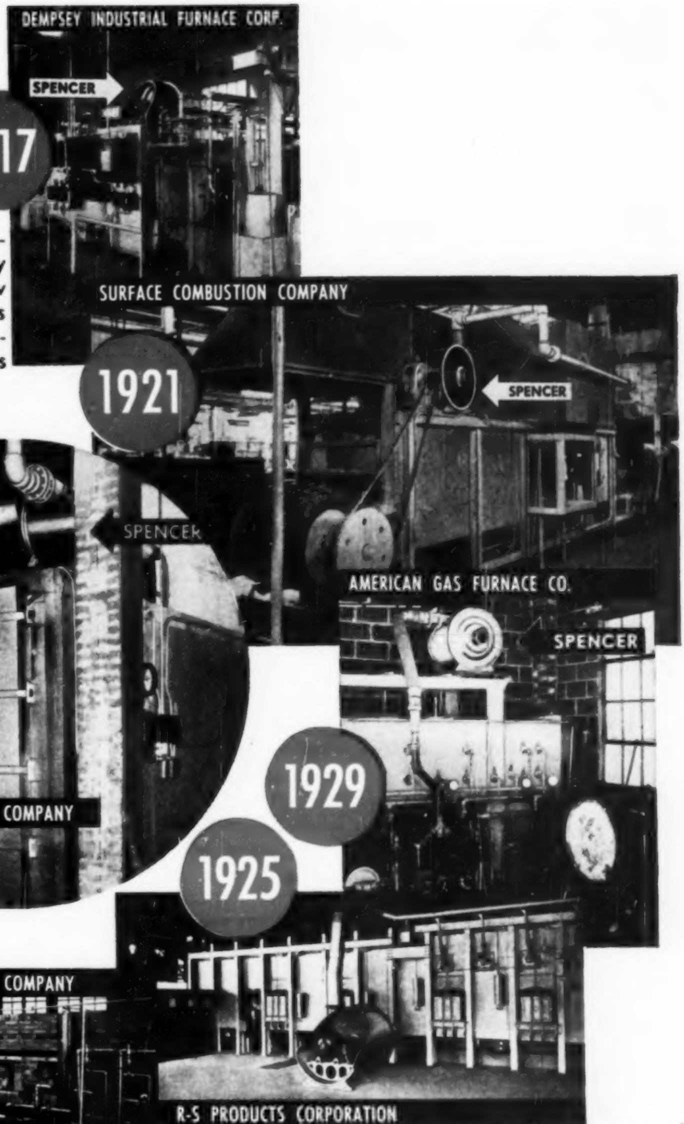
40th Anniversary Year

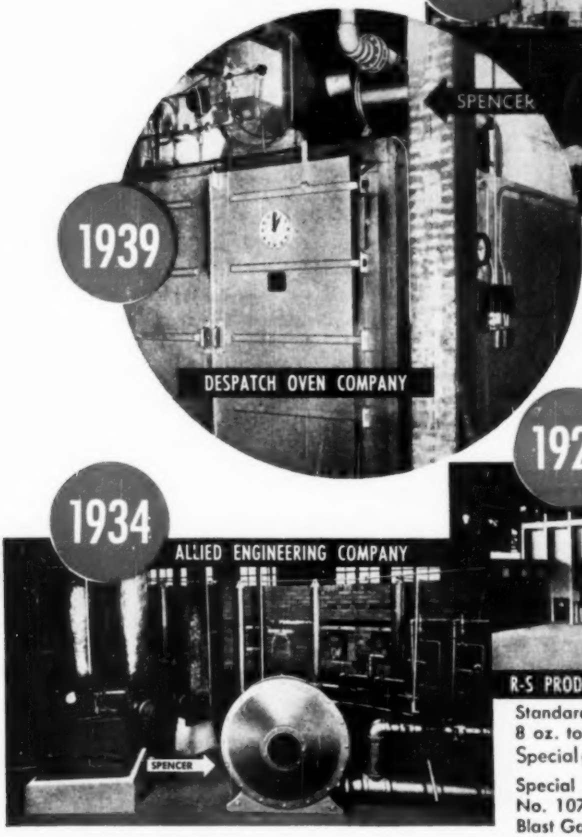
Acheson Colloids Corporation

Port Huron, Michigan

Since 1917

The first Spencer Turbo was installed in 1917. Many of the early machines are still in service. A few of the equipment manufacturers that have used Spencers consistently (see dates) for many years are represented on this page.





Standard sizes from 35 to 20,000 cu. ft.; ⅓ to 800 H.P.; 8 oz. to 10lbs. Single or multi-stage, two or four bearing. Special gas-tight and non-corrosive construction available.

Special Spencer Bulletins are available as follows: Data, No. 107, Gas Boosters, No. 109, Four Bearing, No. 110, Blast Gates, No. 122, Foundries, No. 112 and the General Bulletin is No. 126.

359-F

SPENCER HARTFORD

THE SPENCER TURBINE COMPANY • HARTFORD 6, CONN.

TURBO-COMPRESSORS

The solution of the above question is an obvious one. Let's say that in each furnace cycle the fuel consumed in heating the metal itself of the cast iron boxes, pictured at the right above, is $60. Then, since the "Pressed Steel" sheet alloy boxes, pictured at left, weigh 2/3 less, a carload of them could be heated for roughly $40 less. When this substantial amount is multiplied by the number of heats in a year it develops into a real slash in production costs.

If this possibility of fuel savings has not been canvassed may we suggest that the number of BTU's consumed in heating your annealing or carburizing equipment be computed. The possible savings may point up a reason why, for example, 80% of the nation's heat treaters use "Pressed Steel" carburizing boxes. As pioneers of light-weight sheet alloy heat treating equipment, we offer you a wealth of experienced engineering assistance and production know-how. Send blue prints or write as to your needs.

THE PRESSED STEEL CO. *Light-Weight* Heat-Treating Equipment SAVES 4 WAYS

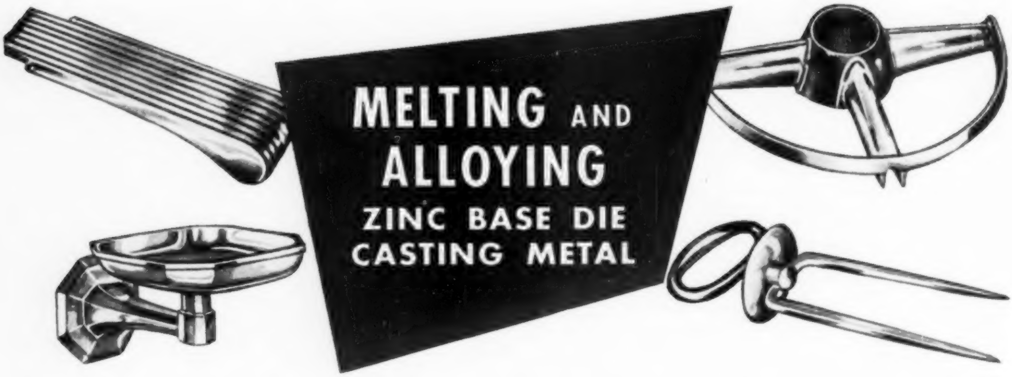
Require less fuel and time to attain pot heat. Handle easier. Last from 2 to 20 times longer. Save space, increase furnace capacity.

"Pressed Steel" light-weight sheet alloy heat-treating units are furnished in any size, as well as in any design or metal specification. Complete line of equipment for every purpose: annealing and carburizing boxes, covers, baskets, racks, tubes, retorts, etc.

THE PRESSED STEEL COMPANY
of WILKES-BARRE, PENNSYLVANIA

Industrial Equipment of Heat and Corrosion Resistant WEIGHT-SAVING *Sheet Alloys*

☆ ☆ ☆ OFFICES IN PRINCIPAL CITIES ☆ ☆ ☆



Reverberatory Furnace Operations

GERITY-MICHIGAN CORPORATION

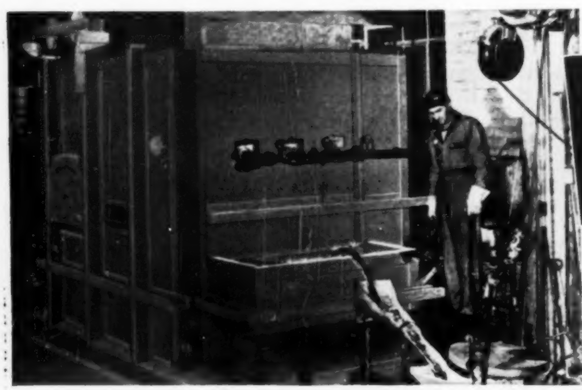
Demonstrate High Temperature GAS Firing Technique

REVERBERATORY FURNACES designed to increase the production of zinc base die casting alloys have expanded melting and alloying capacity almost 50% over conventional pot melting. At Gerity-Michigan Corporation, Detroit, these Gas-fired furnaces operate on practically continuous schedules with savings of 35% to 40% based on time-saving methods and more efficient fuel utilization.

This application demonstrates the flexibility of GAS for industrial heating processes in high temperature ranges. But it also emphasizes the role of GAS in the development of production-line equipment for non-ferrous metals.

R. L. Wilcox, metallurgical engineer and Vice President of Gerity-Michigan Corporation describes the furnace and its application—"**This 18-ton Gas-fired reverberatory furnace has the advantage of extended service life, more efficient fuel utilization, closer temperature control, simplified alloy analysis.**"

Regardless of the type of heating operation or heat-treating process, GAS is the ideal fuel for any temperature requirement, or any production-line application. The characteristics of GAS—speed, flexibility, economy, controllability—are useful features for every industrial heating need. In view of rapid developments it's always worthwhile to keep your eye on what's new in Modern Gas Equipment.



MORE AND MORE...
THE TREND IS TO GAS
FOR ALL INDUSTRIAL HEATING

Gas-fired reverberatory furnace designed and constructed especially for melting and alloying zinc base die casting alloys at Detroit Die Casting Division.

AMERICAN GAS ASSOCIATION

420 LEXINGTON AVENUE **NEW YORK 17, N. Y.**

more HOME APPLIANCES PER TON—

more DURABILITY PER APPLIANCE WITH

N-A-X HIGH-TENSILE STEEL

N-A-X HIGH-TENSILE saves three ways when used in the manufacture of home appliances.

Because of its inherent high strength and toughness, up to 33% more units per ton can be produced than with ordinary carbon sheet steel.

Because sections can be made lighter without sacrifice of strength or durability, handling weight can be reduced, packaging and shipping costs lowered.

N-A-X HIGH-TENSILE provides a smoother surface texture when drawn, permitting substantial savings on finishing.

Why not investigate the possibilities of N-A-X HIGH-TENSILE for your products?

MAKE A TON OF SHEET STEEL GO FARTHER

Specify—

N·A·X

HIGH-TENSILE STEEL

GREAT LAKES STEEL CORPORATION

N-A-X Alloy Division • Detroit 18, Michigan

UNIT OF NATIONAL STEEL CORPORATION

LINDBERG BOX TYPE FURNACE

B-2 and B-6

●

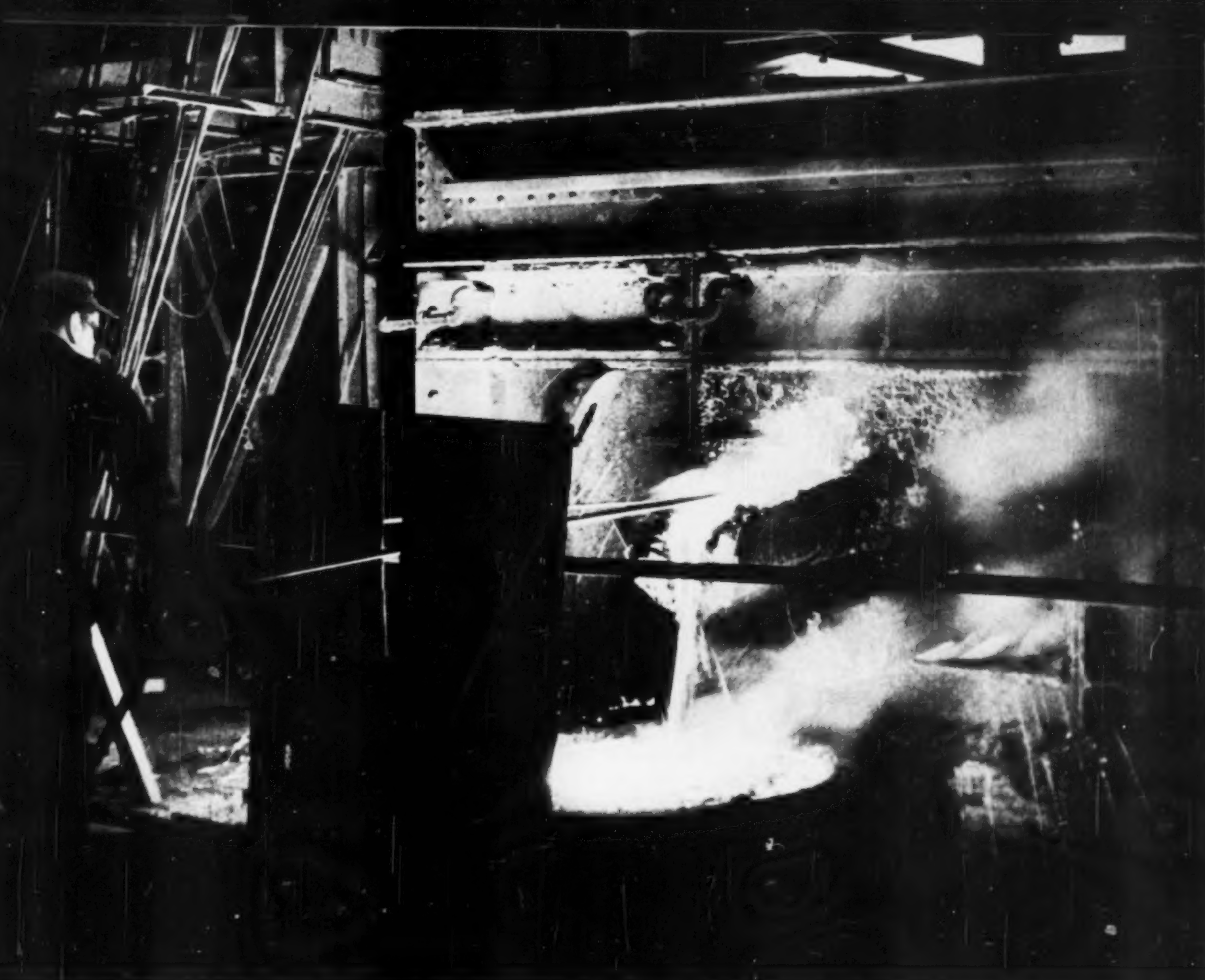
Economy of Operation
Long Element and Furnace Life
Accurate Heating Control

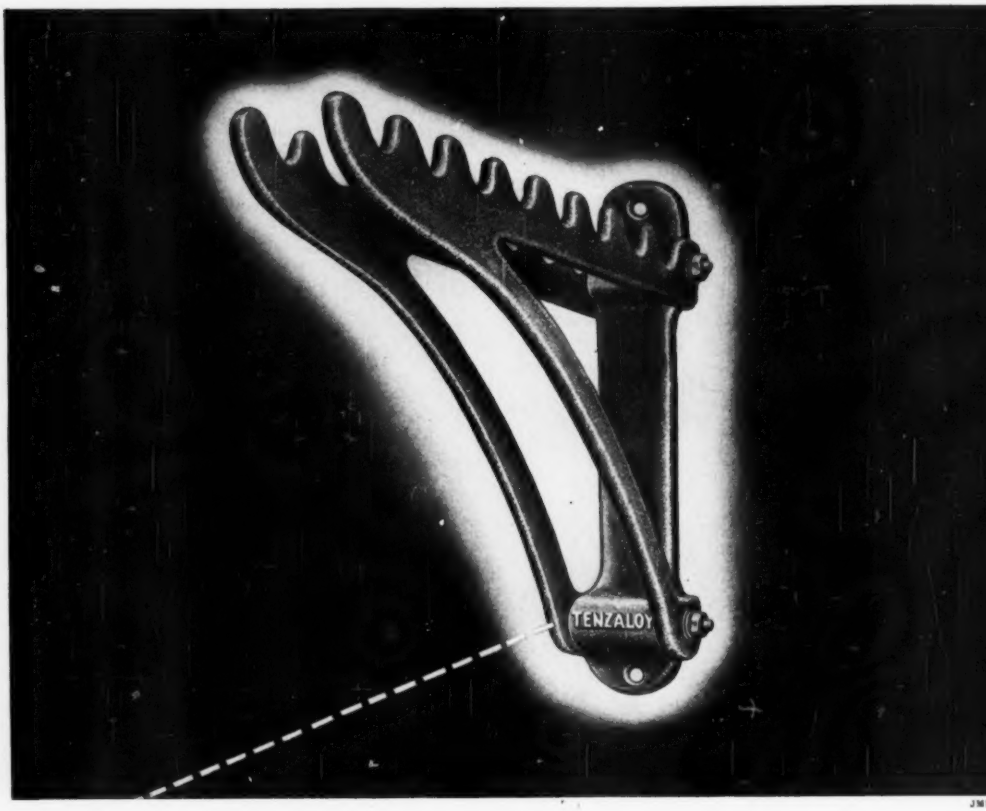
The Lindberg Box Furnace is a compact economical furnace for handling many types of heat treating jobs required in the modern laboratory. Ash determinations, fusions, ignitions, assaying, drying precipitates and heat treating small parts are several of the many useful applications for which this furnace can be used.

The Furnace is constructed as a complete self-contained unit. A P2L2 Manual Pyrometer and Input Control is supplied as a separate unit so that it can be mounted for the convenience of the operator. If full automatic control is desired, a 291 "Lab-Type" indicating pyrometer controller is furnished.

H-25900 Furnace No.	B-2	B-6
DIMENSIONS		
Overall length . . .	25"	30¼"
Overall width. . . .	19"	22"
Furnace height . . .	22"	26"
Furnace width. . . .	16¼"	19¼"
Clearance height . .	27¾"	32¾"
Chamber depth . . .	10¼"	14¼"
Chamber width . . .	4½"	7½"
Chamber height . . .	4"	5½"
SPECIFICATIONS		
Power Rating—watts .	1800	4000
Power Service. . . .	115 or 230 Volts 60/50 Cycles	230 60/50 Cycles
Shipping weight . . .	380 Lbs.	500 Lbs.
Price with P2L2 Control	$374.00	$468.00
Price with 291 Automatic Control . . .	490.00	583.00

HARSHAW SCIENTIFIC
DIVISION OF THE HARSHAW CHEMICAL CO.
CLEVELAND 6, OHIO





For High Strength without Heat Treatment!

This aluminum casting is a tool rack for shovels, hoes, rakes and other heavy garden equipment. The Max Manufacturing Company of San Jose, California, chose Tenzaloy, Federated's new aluminum casting alloy, for the fabrication of the product "because of its great strength as cast, without the necessity of heat treatment." Tenzaloy tensile strengths average 29,000 psi as cast, and 35,000 psi with 10-14 days aging at room temperature.

This manufacturer also states that Tenzaloy is his choice because "standard foundry procedures can be followed in its use, and the end product is a nice clean casting with a minimum of fuss, bother and expense."

Tenzaloy also has excellent ductility, impact resistance, castability, machinability, corrosion resistance and superior polishing characteristics. Send now to Federated's Dept. SJ for literature that describes Tenzaloy more fully.

Federated produces many other non-ferrous metals and alloys, including brass, bronze, aluminum and magnesium ingot; solders; type metals; die casting metals and fabricated lead products. Sales offices in 25 cities across the nation.

Federated METALS

Division of American Smelting and Refining Company, 120 Broadway, New York 5, N.Y.

Gas-fired carburizers at the Bonney Forge & Tool Works, Allentown, Pa., are required to stay on the job 24 hours a day, 6 days a week.

Low Heat-Hour Costs for 30 Years with NICHROME*

FOR 30 years, world-famous Bonney tools have been heat-treated in Nichrome retorts designed and cast by Driver-Harris for use in American Gas Furnace Company carburizers.

Employed in every carburizing unit at the Bonney plant, these retorts have proved unexcelled for efficiency, economy and *long life.*

The lighter construction afforded by Nichrome results in higher heat transfer and less heat consumption, and the superior heat and corrosion-resistant properties of this outstanding alloy assure top-level performance over longer periods, with minimum furnace downtime. Result: maximum production at *lowest heat-hour costs.*

Whatever *your* heat-treating problems, you will find Nichrome, and the other D-H cast alloys, Chromax* and Cimet*, unsurpassed for normal applications, indispensable when meeting unusually severe conditions. So send us your specifications. We will gladly make recommendations based upon your specific requirements.

*Nichrome is manufactured only by

Driver-Harris Company

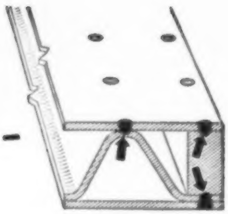
HARRISON, NEW JERSEY

BRANCHES: Chicago, Detroit, Cleveland, Los Angeles, San Francisco, Seattle

SPECIAL PURPOSE ALLOYS SINCE 1899 D/H TRADE MARK REG. U. S. PAT. OFF.

*T.M. Reg. U. S. Pat. Off.

IN PLACES LIKE THESE?



Full Scale

"HELIARC" TORCH SPOT WELDING can do it easily and quickly

Torch spot welding is a new use for inert-gas-shielded arc welding that fills a long-felt gap in sheet metal assembly methods. Spot welds are made by a light pistol-grip torch that requires access to the work from only one side.

Does many jobs

You can use this new HELIARC torch for many types of spot welding work. It is especially useful where the structure is large or of complicated shape because welding is done from one side and no forging pressure is required. You can spot weld ducts, tubes, containers, brackets, handles and many other assemblies. Mild steel, low alloy or stainless steel .030 to .064 in. thick are the metals that can now be welded. Not only can you join sheets of these metals in one to two seconds per spot, but you can also join a sheet of metal to underlying material of any thickness. Thus, corrosion resistant sheets can be spot welded to mild steel plate to provide cladding.

Easy to use

It's no trick to weld with the pistol-grip HELIARC HW-8 Spot Welding Torch. Just press the "muzzle" of the "gun" against the work and pull the trigger.

Low-cost power equipment is another feature of this process that makes it attractive. A regular 300 amp. welding transformer with high frequency unit is all that is needed to supply the power. Power return is by ground lead clamped to the work at any convenient location. A timer control automatically takes care of operating the accessory equipment.

Equipment is simple

Only one hose assembly connects the torch to the accessory equipment which can thus be placed out of the way to leave the entire work area free. The standard hose assembly is 25 ft. long. The hose is about an inch in diameter and contains conductors for power cable, cooling water, shielding gas, and trigger control. Electrode adjustment is easily made by push-button control located on the torch. All of these features make the spot welding torch easy and natural to use and as light and portable as an oxy-acetylene blowpipe.

The ease of use and quality of work done with HELIARC torch spot welding makes it an ideal production line tool. Contact any LINDE office for additional information about this new spot welding process.

Linde
Trade-Mark

THE LINDE AIR PRODUCTS COMPANY

Unit of Union Carbide and Carbon Corporation

30 E. 42nd St., New York 17, N. Y. UCC Offices in Other Principal Cities

In Canada: DOMINION OXYGEN COMPANY, LIMITED, Toronto

M E T A L   P R O G R E S S

Vol. 55 **January, 1949** **No. 1**

Ernest E. Thum, *Editor* Taylor Lyman, *Associate Editor*

Table of Contents

 Published monthly; subscription $7.50 a year in U.S. and Canada; foreign $10.50. Single copies $1.50. Entered as second-class matter, Feb. 7, 1921, at the post office at Cleveland, under the Act of March 3, 1879......The American Society for Metals is not responsible for statements or opinions printed in this publication. The Editor is sponsor for unsigned and staff articles...... Requests for change in adddress should include *old* address of the subscriber.

METAL PROGRESS

Published by The American Society for Metals

Volume 55; January to June, 1949

CRITICAL POINTS

By the Editors

Stainless Sheet in Mass Production

TO Canton and Massillon to inspect beautiful new equipment installed by Republic Steel Corp. for making stainless steel sheet, and marveled at the amount of this noble metal that is now being made and sold. Twenty-five years ago American production was limited to a few hundred tons of the cutlery analysis; now continuous sheet and strip mills of most modern design are necessary to make 1948's 600,000 tons of all kinds of "stainless". Perhaps this does not sound like so much in view of our total production of steel ingots crowding 85 million tons, but still it represents a tidy sum of money when you remember its average price at the mill of about $600 per ton (maybe $800 for sheets and strip). Its utility soon outgrew the original use for cutlery where the word "stainless" is truly applicable; now it goes into all sorts of places where its permanence — over-all resistance to corrosive surroundings — is the main requirement. Consequently, Republic's trade-mark "Enduro" has much to recommend it as a generic name. L. S. Hamaker, assistant general sales manager, said that no important new field of consumption had been uncovered during these postwar years while production was doubling — rather that the old uses were becoming universal, and minor uses in old industries continually appearing. The food industry — in all its ramifications of food processing, meat packing, dairying, restaurants, kitchen equipment — is the largest consumer, taking as much sheet as it can get and crying for more.

The principal steelmaking advance, in the opinion of Chief Inspector F. O. Reese, is the ability to make wide sheets. Republic's prewar Plant No. 1 could make coils 30 in. wide, but edge cracking in the hot mill was epidemic. Some analyses were worse than others; nevertheless success in making 62-in. strip-sheet in the new Plant No. 2's real mass-production equipment has required numberless adjustments in the minutiae of mill practice clear back to the melting sheet. One potent factor in this advance is as nice a metallurgical laboratory as ever I did see in a steel plant — indeed it is unique. Whenever any coil fails to work as expected, the foreman can walk over with a sample, test pieces can be milled, pulled or bent, hardness read, Erichsen tested, melt records consulted, and the trouble diagnosed in 15 or 20 min. There is even polishing equipment and a binocular microscope.

It is a truism that the buyer of stainless buys a surface. A logical extension of this idea is that stainless should be finished in a mill that is meticulously clean — maybe air conditioning is in prospect. Less apparent is the truth of Assistant District Manager Ernest R. Johnson's statement that any lapse in general housekeeping is immediately reflected not only in the output but also in

the accident rate. Requisite cleanliness, also, is not too easy in a mill where heat treating and pickling require extremes of practice — temperatures up to 2000° F. and such unfriendly acids as nitric and hydrofluoric.

Gun Tubes and Liners

TRAVELLED to Boston to talk before the ⊕ Chapter about some interesting things that have happened to the stainless and heat resisting steels in the last few years — such as the use of oxygen for melting low-carbon heats, the sigma phase, some special-purpose compositions with manganese, copper or aluminum, the improved heat and stress resistant alloys for gas turbines, and the chances of making real super-duper alloys — and had a chance to revisit Watertown Arsenal where everything is quiet as peace. Watertown's laboratory functions primarily as a metallurgical research institution for the whole Army Ordnance Department, but now the immediate problem is to recruit adequate personnel to replace the wartime experts who have re-entered industrial or educational work. . . . . Peter Kosting — long-time student of guns — graphically showed the results of 20 years' work of designers, ballisticians and metallurgists which have decreased the weight of 75-mm. field gun barrels by half, and from his remarks gathered that one of the limiting factors is now the temperatures momentarily generated by the powder. Since desirable propellants can actually melt a thin layer of steel near the breech, further improvements will come through more infusible metal for liners. (One possibility for making such necessary thin-walled tubing of refractory metal — refractory both as to melting and as to workability — is by feeding the metal as a powder through a spray gun and building up a sufficient layer on a revolving mandrel, then passing this slowly through an induction coil to fuse the compacted metallic particles, and finally stripping the thin-walled cast tube from its center.) . . . . John F. Wallace, in charge of the experimental foundry at Watertown, demonstrated the workings of a centrifugal casting machine brought over from Germany. This utilizes a thin-walled mold, water jacketed, and therefore is capable of casting one gun tube every 30 min., one-quarter of the time required to air-cool the thick-walled molds used in American machines. A thin layer of dry sand is spread inside the mold to protect it; the incoming molten metal passes through a spinning, open-bottomed "jug" and therein acquires a rotational path that does not wash away this protective sand. . . . . The advantages of cast over forged barrels are that they are made in relatively cheap and noncritical machinery; they do not have the transverse weaknesses of hollow forgings; they can be heat treated to equivalent longitudinal properties.

Rust and Wear

AT Massachusetts Institute of Technology this graduate of a fresh-water college is always overpowered by architectural magnitudes, yet the buildings still grow in number and size; the undergraduate enrollment likewise. Imagine teaching the elements of iron foundry practice by laboratory exercises to 600 sophomores! Postgraduate instruction also occupies an important amount of faculty time and laboratory space . . . Talked long with Herbert H. Uhlig, about his researches in the corrosion laboratory and his editorial problems on the comprehensive "Corrosion Handbook" just published for the Electrochemical Society. As to studies into corrosion, it is no longer sufficient to dunk a piece of metal into acid and weigh the loss. Uhlig is now coming to grips with what happens to a vacuum-cleaned surface of stainless steel when a tiny trace of gas or liquid reaches it. Does a single layer of gaseous atoms attach itself more or less at random, or do metallic atoms come up out of the surface layers and build a chemical compound with a regular space lattice? Passivity, or resistance to corrosion, has been plausibly explained on both these suppositions — namely an adsorbed layer of atoms, and a thin layer of protective oxide. Even though the hypothetical oxide is several times thicker than the atom (if the words "thick" and "thin" have any real meaning at such infinitesimals), it is still too thin to be studied by electron diffraction methods. The contact potentials of the two surfaces *are* quite different, however, so Uhlig's apparatus consists of vacuum pumps, gas handling devices, and electrical meters of precision and sensitivity . . . . Methinks this information, valuable as it undoubtedly will be to the study of corrosion, will also have some value to students of lubricants and wear. Rust and wear — these are the two main enemies of metal; otherwise our tools and machines might be everlasting.

HOW MANY readers do you suppose have written The Editor telling him that the characters meaning "Chinese language" on page 697 of November's issue are upside down and also read in the wrong direction — that is, readers with American names — with the Far East yet to be heard from?

Glass Versus Metal for Containers

ONE EXCUSE — if excuse be needed — for a metallurgist to visit an establishment devoted to glass manufacture is that glass makers, strangely enough, call the molten bath "metal". The "plant" inspected at Toledo really was a recently built laboratory of Owens-Illinois Glass Co. for studying customers' problems. A wide range of services is tendered — free — to users of glass containers by a staff of 350 people, including designers of labels, wrappers and cardboard displays, promotional and survey experts, bacteriologists, organic chemists and metal specialists. Specially inert glass containers and closures of plastic, fiber or metal are formulated for delicate substances. Tougher glass and more shock resistant shapes are developed for milk and beer bottles that make many round trips. On the other extreme, throwaway bottles are needed to compete with beer cans . . . If the glass people don't chisel into the tin can business it certainly will not be for the lack of an intelligent, well-financed try.

Toledo, City of Glass and Jeeps

TO TOLEDO, hub of the glass industry, to repeat a talk, "Implications of Atomic Energy", before a joint meeting of American Society for Metals and American Chemical Society, and was rewarded by as large, attentive and intelligent an audience as a speaker could wish for — an indication that the subject is still unclear in the minds of many citizens even three years after they heard of a far-off Japanese city called Hiroshima. Few prophecies were made, thus profiting from the recently proven fallability of "scientific" forecasts; even the observable present trends are hard to appraise, since the area of public knowledge about developments in atomic energy both at home and abroad is so small.

In that same city of Toledo, found that the wartime Jeep had sired a line of progeny, all members gratifyingly bearing a strong family resemblance. The father of the line was functional in the strictest sense of of the word; everything that went into the Jeep had to pass three searching tests: Was it necessary? Was it adequate for the vehicle's service? Was it economical to make? The result was a machine that was prized by G.I.'s (even though it bumped their backsides thumpingly); it was a bus beyond the fondest dreams of boys from China to Maine. Many such will pray that there can be at least *one* escape from the slick metal shrouds that the Detroit motor magnates have draped around and about a motor, transmission and wheels.

Touring the Willys plant with Nelson Meagley (metallurgist promoted to manager of quality control), fell into a discussion with Glenn Pelton, in the forge shop, about the comparative merits of relatively slow heating in conventional fuel-fired furnaces and rapid heating by electric induction or by high-intensity gas flames. Aside from reluctance to scrap serviceable equipment, dear to the heart of the hammermen, fast heating requires billets of notably better surface — sometimes not so easy to get in these days of steel scarcity. Small surface flaws can usually be scaled off during a soaking heat; on the other hand, scale wears out furnace hearths and forging dies and is sometimes pounded into the part. Minimum scale is obviously necessary for a hot coining or restriking operation. Heating by electric induction is best fitted for rounds, flats and such simple shapes; radiant gas equipment seems more adaptable for reheating semifinished forgings.

Large Cylinder Liners, Induction Hardened

NATIONAL SUPPLY CO. manufactures oil-field equipment that is in enormous contrast to automotive parts. For example, the double-throw crankshaft for the largest sludge pump in the National line (photographed on p. 469 of the October issue) weighs 7000 lb. and transmits 825 hp. at 65 r.p.m., whereas the four-throw crankshaft for the Jeep engine weighs 46½ lb. and transmits 63 hp. at 4000 r.p.m. However, this bulk is in line with the "hell-for-stout" oil industry, where field equipment is classed as portable if it weighs less than 25 tons! Shop equipment is correspondingly heavy . . . Chief Metallurgist Robert Adams exhibited a machine as large as a steam hammer for hardening the internal bores of sludge pump liners. (It appears that as the well gets deeper and deeper, the liquid mud pumped down to the drill bit needs higher and higher pressure, so the linings of the pump cylinders and the pistons are correspondingly replaced by others of smaller diameter.) Cylinder liners are made of 0.50% Cr, 0.55% C steel; in size they may be as much as 10¼ in. outside diameter by 30 in. long; internal diameters may be from 8½ to as little as 4 in. To resist scour the internal surfaces are hardened to C-60 to C-63 with depth to 50% martensite of 0.130 to 0.080 in., varying inversely with the wall thickness. The hardening machine clamps the liner in a vertical position. Up the axis creeps an inductor head at ½ in. per sec.; it carries 3000-cycle current

and is immediately followed by a quenching head. Speed of inductor is automatically varied to take care of excess heat requirements at start and to avoid overheat at the end. Floor to floor time is 4 min. Replacing inductor and adjusting controls for a liner of different diameter requires 1½ hr. The water quenched liners are subsequently airdrawn 2 hr. in a Despatch pit furnace at about 400° — low enough so the Rockwell hardness is reduced not more than a point or two. This is obviously a quicker job than the carburizing cycle formerly used. It is commonly said that excess carbides in the microstructure are necessary to resist scouring wear; excess carbides do not exist in hardened 0.50% carbon steel, of course, but such liners appear to stand up in service just as well as the high-carbon carburized liners.

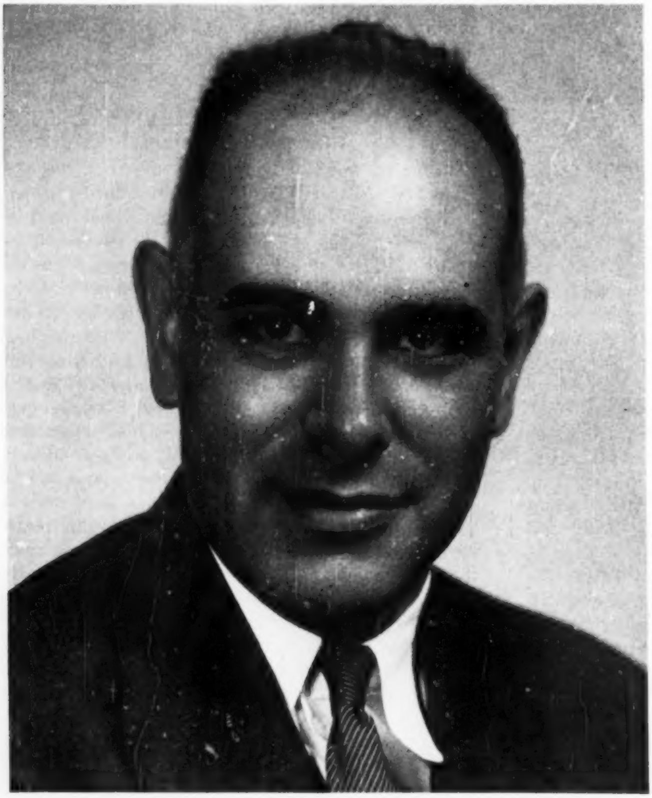
Addition to Editorial Staff

IT GIVES me much pleasure to announce the appointment of TAYLOR LYMAN as Associate Editor of *Metal Progress*, now that he has completed the three-year task of organizing and editing the 1948 edition of "Metals Handbook". The success of this monumental work is proof that, through Dr. LYMAN's efforts, the editorial coverage of *Metal Progress* magazine will be enhanced in variety and scope.

Metal Progress was established by the American Society for Metals in 1930 under the editorial direction of ERNEST E. THUM, who brought to the work unusual experience in metallurgical engineering, editing, and technical publicity. The Editor's aim for the magazine was to live up to its title — namely, to publish information on advances in metallurgy (scientific and technical progress in the production, fabrication and use of quality metals and alloys) in common language free from mathematics, abstractions and scientific jargon. Editor THUM's success in this respect may be judged by the citation (at the recent convention in Philadelphia) by the Committee on Distinguished Service Awards "for gathering, interpreting, and presenting information on alloy steels in all their aspects".

The Board of Trustees of the American Society for Metals believes that the original editorial objective is still the prime reason for the existence of *Metal Progress*. In fact, there is to be no pause in our efforts to maintain its unique position among American technical magazines. Hence the appointment of Dr. LYMAN as Associate Editor. We believe that, with this team of outstanding editors, THUM and LYMAN, the members of the American Society for Metals and readers of *Metal Progress* may confidently expect that the scope and coverage of the magazine will be advanced in important measure.

W. H. EISENMAN
Secretary
American Society for Metals



Taylor Lyman
Associate Editor, *Metal Progress*

KILLED BESSEMER — A NEW STEEL OF HIGH QUALITY*

By E. G. Price
Vice-President in Charge of Operations
National Tube Co.
Pittsburgh

BESSEMER STEEL has been made in America since 1864, the process thus being six years older than the now dominant openhearth. The basic principles remain unchanged, although many variations have been tried and many improvements made. Acid linings and bottom-blown vessels are used exclusively in America for making ingot steel.

The early use of the converter was primarily for the manufacture of rail steel. At the present time (other than duplexing with the openhearth) the process is used principally in the production of screw stock, buttwelded pipe, seamless pipe, flat rolled products, and for steel castings. The future of bessemer steel has many commercial possibilities since the inherent economic advantages of the process are being given a renewed appreciation.

Economic Considerations

The cost of building a bessemer plant is appreciably less than that of an openhearth plant of equivalent capacity. However, greater blast furnace capacity is required, as only a small amount of scrap is used in the process, and this was probably one of the factors which were responsible for the shift from converter to openhearth production during the past 40 years. With proper facilities in an integrated plant, the cost of producing bessemer ingots over a period of years should be less than that of openhearth ingots. When a shortage of scrap exists and its price is high, the bessemer plant not only has an economic advantage but is in a better position to make steel.

Consequently, the economic relationship of converter to openhearth production is influenced by the availability of steel scrap. The bessemer process uses about 10%, while the stationary openhearth process ordinarily has 35 to 50% of scrap in the charge. Furthermore, the bessemer process is more than self-sufficient, as the crop-ends from the blooming mill alone produce about 15%, and additional scrap is produced in further processing. The stationary openhearth process produces a similar amount of scrap but constantly uses more than it produces, so the deficit must be purchased from out-of-plant sources.

At the present time, the production of converter steel is apparently not great enough for the correct balance of processes in the steel industry. If the present unbalanced condition, which is related to a shortage of scrap, continues for a sufficient period, economic pressure will bring about conditions which have existed in Europe for many years, and will result in increased bessemer production.

*Extracts from a paper presented before the regional meeting of the American Iron and Steel Institute in Cleveland, Sept. 29, 1948.

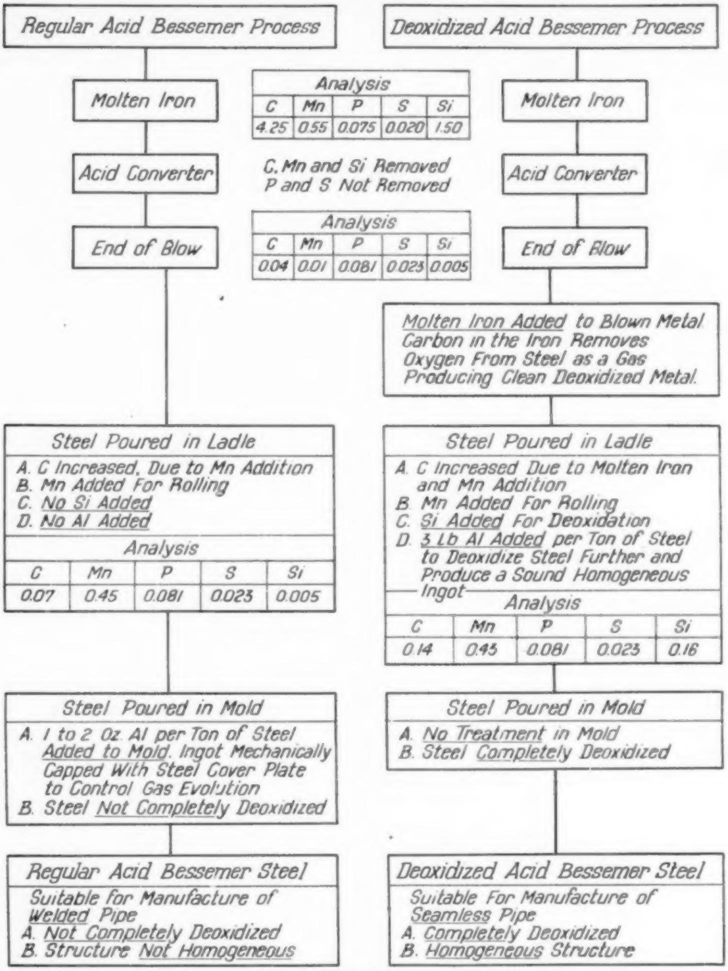


Fig. 1 — Differences Between Manufacturing Practices for Regular and for Deoxidized Acid Bessemer Steels

Metal losses in the converter are comparable with those of stationary and duplex openhearth practice, despite the pyrotechnic display which impresses the observer. This situation should improve in the future as technological advances are applied.

E. C. Wright has already described the process for making killed converter steel (see *Metal Progress* for October 1946, p. 662). In outline it is shown in Fig. 1, parallel to the conventional process for making incompletely deoxidized steel.

Killed Bessemer Steel

It will be observed from the flow sheet at the left that, in the new practice, molten iron is added to the vessel at the end of the blow, as ordinarily determined by the drop of the carbon flame. Temperature is sufficient so that reaction between carbon in the iron and oxygen dissolved in the steel is rapid and removal of oxygen is therefore as a gas rather than as a nonmetallic inclusion which may be trapped in the solid steel. Ferromanganese and ferrosilicon are added to the vessel or the ladle, preferably the former. Final deoxidation is in the ladle with aluminum, to insure fine-grained steel and for nitrogen fixation. Killed bessemer steel is therefore distinctly different from regular acid bessemer steel, due to this deoxidation practice.

Bessemer Steel for Welded Pipe

In 1887, Thomas J. Bray of the Riverside Iron Works at Wheeling, W. Va., began making buttwelded and lapwelded pipe of soft bessemer steel. Up to that time, wrought iron was the only material used for welded pipe and tubes. Bessemer steel proved to be the equal of wrought iron — and actually superior in many respects. Today, conventional bessemer steel is used extensively to produce welded pipe by the continuous and noncontinuous welding processes. In 1946, about 1,500,000 tons of buttwelded pipe were made in the United States, practically all from acid bessemer steel.

Properties — Welded pipe made from bessemer steel has a chemical composition approximating

0.06 to 0.09% carbon, 0.30 to 0.60% manganese, 0.075 to 0.095% phosphorus and 0.030 to 0.045% sulphur. In some of the specifications phosphorus of 0.110% max. and sulphur of 0.065% max. is specified.

Mechanical properties of this material will conform to 30,000 psi. min. yield strength, 50,000 psi. min. tensile strength and 18% min. elongation in 8 in. In addition to tensile tests, welded tubular products have to withstand bending, flattening and hydrostatic testing requirements, depending upon the use.

Applications — Welded pipe is usually made into two separate classes, standard and extra-strong, differing in wall thickness. Standard pipe is intended for ordinary uses in steam, water, gas and air lines where operating pressures are low. Extra-strong pipe is used where higher internal pressures or greater column loads are to be sustained. Where corrosion is a problem, the pipe is usually galvanized.

Seamless Pipe — Bessemer seamless pipe requires thoroughly deoxidized steel, a distinctly different product from regular acid bessemer steel, the equivalent to openhearth steel, for piercing is a difficult operation requiring a billet of uniform density and forging characteristics. Satisfactory seamless tubes have rarely been produced with uniform practice from either bessemer or openhearth rimmed or capped steels. Commercial production of bessemer seamless pipe by National Tube Co. according to the process outlined in Fig. 1 was initiated in the latter part of 1937. Since then over 806,000 tons of seamless pipe have been produced from this type of steel.

It was soon determined that the properties were fundamentally different from those of regular acid bessemer welded pipe. Typical chemical and mechanical properties of Grade B seamless pipe are summarized in the frequency distribution charts in Fig. 2.

Steel made in this way has also been very satisfactory for oil well casing where resistance to collapse from external pressure

Abandonment of lapwelded pipe manufacture about 10 years ago led the U. S. Steel Corp. to study the possibilities of bessemer steel in other applications, specifically for making seamless tubes. E. C. Wright described these experiments in *Metal Progress* for October 1946 ("Killed Bessemer Steel for Seamless Tubing"). Mr. Price now discusses the commercial and economic conditions that forecast a new lease on life for bessemer steel for the manufacture of products requiring fully-killed ingots—products that heretofore have been made almost exclusively from openhearth or electric steel. In the present day of high-priced scrap, the bessemer converters—requiring no out-of-plant scrap—are in a better position to produce steel than the openhearth plants.

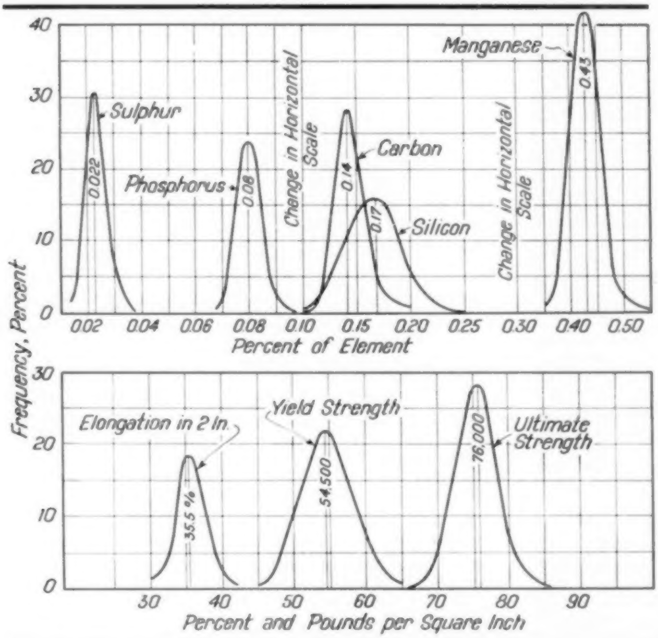


Fig. 2 — Distribution of Analytical and Tensile Results of 2200 60-Ton Heats of Deoxidized Acid Bessemer Steel for Grade B Seamless Pipe

is desirable. For such services a higher carbon is often used — Grade J-55. The average chemical and mechanical properties of high-carbon Grade J-55 bessemer seamless from 1400 tests obtained in one of National Tube Co.'s mills during 1946 were carbon 0.37%, manganese 0.96%, phosphorus 0.085%, sulphur 0.024%, silicon 0.19%, yield strength 67,494 psi., ultimate strength 105,125 psi., and 28.4% elongation in 2 in.

Collapse tests made on many sizes of A.P.I. Grades H-40 and J-55 casing show that the latter seamless casing is superior to openhearth seamless. Average figures for casing with a minimum tensile strength of 70,000 psi. are shown in Table I.

The toughness of steel is usually evaluated by the Charpy impact test. The impact properties at various temperatures of bessemer seamless are almost identical with openhearth steel, killed with silicon and aluminum, as used for seamless pipe (medium carbon, Grade B steel made to A.S.T.M. Specification A-53).

The susceptibility of Grade B bessemer seamless to embrittlement by cold work is similar to that of various types of openhearth steel used for seamless pipe. Such characteristics are usually determined by Charpy keyhole notched impact tests of cold worked and aged specimens.

Considerable quantities of Grade B bessemer seamless pipe used in place of openhearth seamless have exhibited satisfactory welding and other fabricating characteristics; many high-pressure gas lines have been satisfactorily welded. The material has also been hot swaged, hot bent, Van Stoned and threaded in a manner similar to openhearth steel. For a similar carbon and manganese content the yield strength of as-rolled bessemer seamless is usually 10,000 to 15,000 psi. higher than openhearth seamless.

Photo by Henry M. Mayer

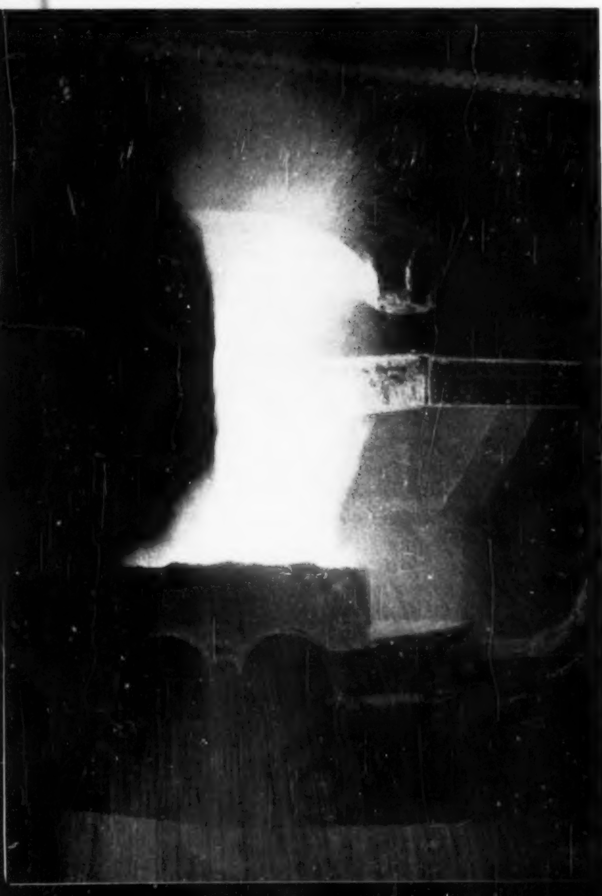


Table I — Resistance of Pipe to External Pressure

D ÷ T *(a)*	Openhearth *(b)*	Bessemer *(c)*
15	6000 psi.	7200 psi.
20	4000	4900
25	2750	3500
30	1900	2400

(a) Pipe diameter divided by wall thickness.
(b) Basic openhearth steel, 70,000 psi. min. tensile strength.
(c) Deoxidized acid bessemer steel, 70,000 psi. min. tensile strength.

The properties of bessemer seamless steel at elevated temperatures have been investigated at the United States Steel Corp. Research Laboratories by short-time tensile and long-time creep tests. In general, the properties are so similar that the working stresses may be similar to those for openhearth steel made to fine-grained aluminum deoxidation practice. The stability at elevated temperatures of over 100 different steels for a period of exposure of 10 years is now under investigation. It has already been determined that for exposure periods of 10,000 hr. at 900 to 1200° F., bessemer seamless is similar to openhearth seamless with respect to graphitization characteristics.

Recently, a modern creep testing laboratory has been installed by National Tube Co. and the high temperature properties of bessemer seamless and many other types of steel will be evaluated more thoroughly, particularly after long periods of exposure at elevated temperatures.

Applications

While this discussion has been limited to seamless tubular products, it is thought that killed bessemer may be used advantageously in other engineering applications where carbon steels of superior quality are needed.

COORDINATION OF METALLURGICAL WORK AT GENERAL ELECTRIC

By William E. Ruder
Head of the Metallurgy Division
in the Research Laboratory
General Electric Co.
Schenectady, N. Y.

ELECTRICAL APPARATUS is made up essentially of metals, insulation and engineering. Of the metals, copper, aluminum, lead, magnetic core materials, and alloys which will withstand elevated temperatures both from the point of view of oxidation and mechanical properties, are probably the items used in largest amounts. While the General Electric Co. uses great quantities of most of the common metals and alloys, the applications for a large number of these are highly specialized and therefore call for considerable metallurgical skill in their development, selection, specification and use.

For example, in the metals section of the general Research Laboratory in Schenectady 30 research associates and assistants and about 35 laboratory assistants are engaged with the more fundamental studies involving magnetics, structures, transformations, specialized tests, and alloy combinations. The aim is to understand the conditions under which metals flow, yield or fracture, oxidize, corrode or wear — and so anticipate, as far as possible, the large variety and combination of properties which may be called for by the designers in the vast number of electrical mechanisms which are now manufactured.

Aside from the Research Laboratory, there are at least 24 other laboratories in the various works of the company scattered throughout the United States, all of which have some interest in metals. Each of these Works Laboratories employs from one to 32 technically trained men in metallurgical work — depending upon the size and interests of that particular works — whose job it is to evaluate, specify materials and control metallurgical processes in their respective plants. In all there are approximately 150 people technically trained in metallurgy employed by the General Electric Co., assisted by about 100 laboratory assistants. In addition, a number of metallurgists are finding their places in our sales organization.

Generally speaking, it is the primary function of the Research Laboratory to initiate new materials, processes and theories. The Works Laboratories are kept informed of all of these developments through internal publications, committees and liaison staff members; it is their responsibility to see that these new ideas are applied in every phase of the company's metallurgical activities where they may be useful. It is impossible, of course, and undesirable that an attempt should be made to draw a hard and fast line which might tend to prevent the full development of ideas originating anywhere in the com-

Recent discoveries in physical metallurgy, together with the development of new processing and fabrication methods, have caused the General Electric Co. to re-evaluate the important influence of the metal specialist on current manufacturing processes. Long a center of fundamental research, the company's management has continually emphasized the importance of translating rapidly the newly discovered facts and ideas into everyday plant practice. To do this, a proper staff must be created and given adequate authority. In this article Mr. Ruder outlines this situation and shows how the problems are being met.

pany. For this reason activities which might be classified as "pure research" are often carried on in some of the Works Laboratories. Some of these specialize in certain lines dictated by local interest. For example, a well-equipped welding laboratory at the Schenectady Works Laboratory investigates all kinds of electric welding — arc, resistance, and spot welding. This is of direct help to innumerable lines of manufacture, and to our engineers and draftsmen who design apparatus for this purpose.

As complete a correlation as possible is maintained throughout the company by a series of committees made up of men from all of the laboratories and designing and engineering departments interested in a particular line. As an example of this committee system — and these are truly *working* committees — is the one responsible for magnetic materials, the number of which, because of the many highly specialized requirements, is surprisingly large. By this committee system every plant and division of the company has someone on the local staff who is responsible for the advice given to the designers on the properties, cost and availability of core materials, and while this committee-man may not have specific knowledge of all of these, he has a direct line to the source of the information he may need. This same system is applied to welding, heat treatment, foundry practice, metal fabrication, metallography, and high temperature alloys.

Mention has already been made of our very great interest in the properties of metals at elevated temperatures. This interest extends all the way from lead for cable sheathing to the so-called superalloys for gas turbine blades. Copper and aluminum conductors must operate at increasingly higher temperatures without creep or distortion and still retain their high conductivity. Steam and mercury turbines are limited in their efficiency largely by the stability of the materials available for their construction. The gas turbine has so far been able to increase these temperature limits only about 500° — from around 1100 to 1600° F. and perhaps a little higher. In our aircraft gas turbine division, jet engine designs require not only the very high-temperature blade materials, but also increased operating temperatures of other structural members, such as shafting, support frames, and liners. In many instances our research has already provided a suitable material or suggested the line of attack; in other places adequate materials are not yet available despite intensive investigations.

As far as process control is concerned, the company maintains five large foundries for the production of its requirements in cast iron, steel, aluminum, and nonferrous alloys. Metallurgical supervision of these foundries is usually provided by the Works Laboratory where they are located. Again, the production of ductile tungsten and molybdenum requires the most careful technical supervision at every stage. At the Carboloy company, aside from the continued research on hard compounds and metal bonding, experts in machining, drilling, stamping, and drawing of metals are needed to insure proper selection and use of this type of tool material. As another instance, the X-Ray Corp. and the Electronics Department are interested in a variety of metal-to-glass seals, metal-to-ceramic seals, and in the fabrication of many special metal parts. In our Appliance Divisions the chief metallurgical interest is in deep drawing, electrical and heat resistant alloys, welding, bi-metals, and corrosion.

A few years ago, with the organization of a Chemical Department of the company, a Metals Manufacturing Division was also set up to make some of the new metal products originating from our studies. So far this division has confined most of its activities to the manufacture of cast and sintered permanent magnet alloys, magnet assemblies, electrical contacts, and a miscellany of powder metal products. Obviously, all types of new developments in metallurgy cannot be handled in this way, as it would involve activity in all metal-producing fields, yet in this single embryo department five metallurgists are employed in design and production and two in sales.

Perhaps some picture of the scope of metallurgy in the General Electric Co. can be had from a rapid review of the kind of things which have come out of our Research Laboratory in the past.

Alloy research had its beginning in this laboratory back in 1905 in a quest for a high-resistance wire that would stand red heat without oxidation. "Calorite", a nickel-chromium wire, one of the early "Nichrome" series, was the result. The invention of the Arsem vacuum furnace about that same time started a long research (it is still in progress) on the effects of gases in metals and changes in metal and alloy properties due to melting under low pressures.

Tungsten has always been a metal of much importance to the lamp industry. Doctor Coolidge developed an amalgam process for lamp filaments by which a tungsten-cadmium-mercury amalgam was extruded and later baked out by passing current through the wire in an evacuated treating bottle. This process was followed a few years later by the Coolidge ductile tungsten process, one of the first commercial applications of the powder metallurgy technique. The powder metal compact method was later applied to the production of porous and graphitized metal bearings and commutator brushes. The then-mysterious embrittlement of copper in certain furnace atmospheres and the embrittlement of steel springs in some plating solutions led to the study of the effect of reducing atmospheres on copper and the penetration of cathodic hydrogen. Copper brazing in a hydrogen atmosphere and the atomic hydrogen welding process were early and logical developments from this preparatory work and they have been widely applied throughout industry. From copper brazing developed the tungsten contact and one of the first clad metals called "Binel", a common steel coated on both sides with monel metal. By enclosing an electrical resistance wire in an insulator (magnesium oxide) capable of withstanding high temperatures (which in turn was held on in a metal sheath), "sheath wire" was produced, the predecessor of the present "Calrod" unit for electrically heating of apparatus and utensils of all sorts.

To pursue this line of industrial achievements, starting from or related to the early "academic" research on vacuum treatment of metals, it may be noted that a series of studies in intermetallic diffusion developed the fact that metals "cemented" with aluminum resisted scaling to a remarkable degree. Copper so treated was especially corrosion resistant. The "Calorizing" process resulted — and later "Chromizing" and "Boronizing".

From this work it was shown that 8 to 10% of aluminum alloyed with iron gave it almost complete protection against scaling. However, the resulting alloy was very brittle, and its modification with nickel and chromium yielded a very satisfactory cast alloy called "Calite" and a series of aluminum-chromium-iron alloys with unusually high electrical resistance and excellent

Photo by Charles Phelps Cushing

oxidation resistance. These alloys, called "Alcres", have taken on many different commercial names and are still widely used in certain resister applications. Unfortunately, those containing higher aluminum and having electrical resistances up to 225 microhms per cu.cm. had a very low creep strength and so their use for this purpose was definitely limited. However, it was this alloy investigation that led directly and quite fortuitously to the discovery in 1931 of the permanent magnet alloy called "Alnico" and its several present-day modifications.

High-Grade Electrical Sheet

Just about the time this Research Laboratory started in Schenectady, Sir Robert Hadfield, in an English publication on alloys, called attention to the increase in resistivity of iron when small percentages of silicon or aluminum were added. Alternating current systems were at that time attracting the attention of our leading electrical engineers, so that high resistivity was an important item in magnetic cores. The development of the present highly efficient transformer core laminations is an example of a continued research and development calling for the application of all phases of metallurgical knowledge.* First, we had to learn how to roll this new alloy into sheets, then how to reduce all impurities to an absolute minimum by improved furnace practice. The effect of grain size on magnetic properties was determined and a process for its control invented. And finally, having found that grain orientation was a very important factor in magnetic properties, a manufacturing process was developed which so closely controls the rolling and heating processes as to produce (in large tonnage lots) strip whose grains are at least 95% oriented in the desired direction! The present product has reduced the transformer core losses to a tenth of the original unalloyed iron and a fifth of those of the original silicon-iron alloy.

The efficiency of prime movers, depending as it does upon the temperature of operation, gave the Research Laboratory an early interest in the properties of metals at elevated temperatures. Some 25 years ago was begun a study of creep — slow extension under tensile load and high temperature. This interesting testing program has continued at an increasing rate ever since. As operating temperatures increased, rupture testing was added (that is, *time* to rupture a test piece at chosen loads and temperatures). With the advent of the high-speed turbosupercharger (and, more recently, the gas turbine) a constantly expanding program on other effects of temperature and temperature change has been carried on. Some of the alloys developed to meet the requirements of turbosuperchargers could not readily be forged, so the technique of the dental laboratory was adapted to industrial production and a pilot plant was set up to produce all sorts of complicated castings by the lost-wax molding process. This pilot plant was used by government agencies as a training ground for the industrial development of precision casting methods.

Precipitation alloys — that is, alloys like duralumin that quench out soft but harden notably by reheating and holding or aging at appropriate temperatures — are by no means confined in utility to machinery operating at elevated temperatures. Alloys of this sort such as "Trodaloys", aluminum and zinc hardened by small additions of cobalt and beryllium, contact alloys, and bi-metal strips for a number of specific applications are now standard articles in daily use.

The above are but a few of the products of metals research during its 40 odd years in the Research Laboratory. Obviously, an understanding of the fundamentals of metal behavior has always been of primary consideration, and fundamental studies continually bear progeny of surprising industrial utility.

Advanced Training Program

With the increase in the company's size and breadth of interest and increasing appreciation for the need for scientifically trained metallurgists, we started about 15 years ago to build up a metallurgist's "pool" by recruiting each year a few carefully selected college graduates with bachelor's degree, bringing them to the Research Laboratory for a period of one to three years' training with a view to meeting the needs for such men as they develop in the company at large. Several years ago this program proved inadequate and a new advanced scientific program was instituted. This increasing recognition of what the trained physical metallurgist — metal specialist — can contribute to a company with the broad field of interest of the General Electric Co. should be of considerable importance to educators, to prospective engineering students, and to industrialists generally who have not yet appreciated the damage that can arise from a wrong decision as to fabrication or application of a given metal or alloy — and, on the other hand, the great necessity to keep abreast of the rapid advances in the field of quality metals.

*The story is told in some detail in the leading article by Weston Morrill ("Improved Silicon-Irons for Electrical Equipment") in *Metal Progress* for November 1948.

How Much Uranium Have We?

ESTIMATES of the world's uranium resources made by responsible men have varied by extraordinary margins. For example, Robert A. Millikan, Nobel prize physicist, writes in "Electrons (+ and —)" (1947 edition): "Since there are now but two places in the world from which uranium ores can be obtained in appreciable quantities, I do not anticipate that uranium will be used for any major fuel or power purposes." He thus limits himself to known high-grade deposits, estimated in 1946 by Gale Young of the University of Chicago as being equal to 3 min. sunlight equivalent.* Compare this with 15 days, the sunlight equivalent of the world's known coal reserves. On the other hand, Mr. Young estimates that the energy extractable from all the uranium disseminated throughout the earth's crust has a sunlight equivalent of 30,000 years!

The following statements by David E. Lilienthal, chairman, and John K. Gustafson, manager of raw materials operations, U. S. Atomic Energy Commission, at a conference in Denver, Dec. 17, 1948, are therefore important:†

[L] Statements have been widely publicized that there is only enough uranium ore to last a relatively brief period. If these estimates of a short-lived atomic enterprise were correct, this would be very serious news. As explicitly as national security permits, the Atomic Energy Commission wishes to state that the contrary is true.

[L] Let us look at the facts as they are available generally for making such estimates. Before the war, uranium was essentially a byproduct of radium or vanadium ore.‡ Man has just begun to look for uranium; some good prospects are turning up in Canada, to cite only one country. Only a few new important discoveries would change the world supply picture profoundly.

[L] Another rule is that good mines die hard. The comparison of measurable ore reserves with rates of consumption at any time means very little in terms of future supply. The prophets of early exhaustion of petroleum and other nonreplaceable raw materials have found this out to their chagrin.

[L] One factor that obviously has not been taken into account in these pessimistic predictions about the uranium ore supply is our growing technology and its future application to low-grade sources of uranium. Most metals have gone, or are going through, a cycle where high-grade deposits are at first the only commercial deposits. Then gradually large low-grade deposits yield to man's technical ingenuity and become important producers. Probably the record for handling low-grade ores is the recovery of magnesium from the sea. As for uranium, Sweden has already announced that she plans to recover uranium from oil shales. Another important potential low-grade source is the gold ores of the Witwatersrand containing low concentrations of uranium.

[L] The Atomic Energy Commission is responsible for one of the most extensive searches for a mineral that has ever been conducted, and on a world-wide basis. We do not expect that there will be an unlimited supply but there is no sound basis for a conclusion that usable uranium ore supplies will not be available for the indefinite future.

[G] There are four major classes of uranium deposits which are being exploited now or will be exploited in the future:

1. High-grade pitchblende-radium deposits (assaying better than 1% uranium oxide). The better-known deposits are Eldorado in Canada and Shinkolobwe in the Belgian Congo (from both of which the United States obtains uranium), and deposits in the Erz Gebirge in Czechoslovakia.
2. Vanadium-uranium ores of the Colorado Plateau, apparently important only in this country, but at best quite inferior to the high-grade ores as a source of uranium. Ore acceptable at A.E.C. must contain a minimum of 0.10% uranium oxide.
3. Gold-uranium ores of the Witwatersrand, South Africa. The U. S. Geological Survey has been systematically examining tailings dumps in this country to discover if similar byproduct possibilities exist.
4. Oil shales and other marine sediments, including phosphatic beds. Swedish shale deposits containing many millions of tons of "ore" with about 0.02% uranium oxide. (These same geological formations extend northeastward up through Estonia.)

[G] The Colorado Plateau has been the only area in the United States actually producing uranium (a byproduct from low-grade ore mined for vanadium). There were five processing plants in the area, but three were closed near the end of the war. Since idle plants soon disintegrate and become useless, the Commission's plan is to put them back into operation and attain the maximum production justified by existing ore reserves. The decision to undertake a rather extensive development and production program on the Colorado Plateau was based on a number of considerations: The use and conservation of idle facilities; the conversion of underground ore into finished product; and the development of a domestic uranium mining industry adequately staffed with experienced personnel which could be rapidly expanded in an emergency. Though production promises to be small in terms of over-all supply, it will be significant.

[G] In eight months the following has been accomplished: Buying schedules, guaranteeing increased prices for vanadium-uranium ores, have been established. An ore-buying station has been opened. Contracts for the purchase of uranium from the two private plants now operating have been extended. By 1950 all five plants in the Colorado Plateau area should be in full operation.

*"Sunlight equivalent" is a measure of energy representing the amount of the sun's radiation reaching the earth in unit time.

†Authorship is denoted by [L] and [G], respectively.

‡"Minerals Yearbook, 1942" reports 2,821,134 lb. uranium oxide and salts imported 1938-1942 inclusive. Figured as U_3O_8 this amounts to about 240 tons of uranium annually.

SAFE PRACTICES FOR LIQUEFIED PETROLEUM GAS

By E. O. Mattocks
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SAFE USE of liquefied petroleum gas is based primarily on engineering principles. While it is recognized that the human element enters into the handling and using of this as well as other fuels, nevertheless the maximum application of sound engineering can reduce the potential hazards to a minimum. The committee on gases of the National Fire Protection Assoc. has issued "Standards for the Design, Installation and Construction of Containers and Pertinent Equipment for the Storage and Handling of Liquefied Petroleum Gases". These have also been published as standards of the National Board of Fire Underwriters, and have been incorporated in large measure in state laws and municipal ordinances throughout the United States.

Liquefied petroleum gases coming from natural sources (that is, natural gasoline plants) consist generally of propane, isobutane, and normal butane with small amounts of ethane usually present. Liquefied petroleum gases coming from refinery sources have in addition to these products propylene and butylenes, as well as small quantities of ethylene. Cycling condensate plants produce the same hydrocarbons as are derived from natural gas.

Explosibility

Frequently, reference is made to the greater explosibility or flammability of liquefied petroleum gas as compared to other commercial gases. In Table I are given the limits of flammability of most commercial fuel gases and several common hydrocarbons included in liquefied petroleum gases. The limits represent the minimum and maximum percentages of gas in air which will support combustion. It will be noted that the minimum lower limit of flammability for any gas is 1.4% for benzene. The next lower number, 1.7%, is for the butylenes — constituents of liquefied petroleum gas. The maximum higher limit is 74.2%, which is for both carbon monoxide and hydrogen, two major components in carbureted water gas. On the other hand the maximum higher limit for liquefied petroleum gas is 11.1%, which is for propylene. Likewise the maximum spread between the lower and higher limit for any one liquefied petroleum gas is 9.1% gas in air, which is for propylene.

Compared with these data the lower limit for natural gas is 4.8% gas in air and the upper limit is 14.6% — a spread of 9.8%. Similarly the spread for carbureted water gas is 31.3%. It is obvious that the limits of flammability are less for liquefied petroleum gas than for other commercial fuel gases. It is true, however, that the lower limit for liquefied petroleum gases is lower than that for the other commercial fuel gases, which means that it requires less liquefied petroleum in air to reach the flammable range than for other commercial fuel gases.

Storage

Because liquefied petroleum gas can be converted and maintained as a liquid under moderate pressures (despite its low boiling points) it is so transported and stored. The gas industry has established that under normal storage conditions in large containers the liquid temperature will never exceed 100° F.; consequently the vapor pressure of the liquid at this temperature is used as the maximum working pressure in the design of containers. Since propane from refineries will contain varying percentages of propylene which has a vapor pressure at 100° F. of 213 psi. — as compared to propane vapor pressure at 100° F. of 174 psi. — the industry has established a maximum vapor pressure at 100° F. of 200 psi. as representative of commercial propane.

Table II contains design working pressure and a classification of storage containers. Experience has clearly demonstrated that containers designed and constructed according to the code requirements mentioned are amply safe. Railroad tank cars are designed in accordance with the Interstate Commerce Commission's and Assoc. of American Railroads' specifications, while truck tanks and portable containers are designed according to the Interstate Commerce Commission's requirements.

Aboveground storage tanks are supported generally on concrete piers. Frequently the question is raised as to the number of piers required. From a design standpoint, the storage container may be considered as a beam if the tank has been constructed by fusion welding. The beam is adequately supported if only two piers are used. While from a theoretical standpoint it appears desirable to place the piers as close to the ends as possible, in order to secure the reinforcing effect of the dished ends, a strain-gage study made by a large tank fabricator indicated that if the piers are located one quarter of the length from the end they do not produce excessive stresses in the tank. If more than two piers are employed they must be maintained in absolutely perfect alignment (which is almost impossible). Thus the use of more than two piers may actually cause an excessive amount of the weight to be carried by one high pier, thus creating a potential hazard.

Experience has shown that liquefied petroleum gas is not corrosive to the interior of storage containers. Likewise any exterior corrosion of aboveground containers can be controlled or eliminated by proper painting. Therefore allowance for corrosion is not considered necessary in the design of such tanks.

Storage containers are equipped with spring-loaded relief devices to take care of an emergency. Since the tank is designed for the maximum vapor pressure expected to be encountered due to the heating of the contents from atmospheric conditions, the primary purpose of relief valves is to relieve pressure in the event of an exterior fire. To insure the correct sizing and operation of relief valves, they are flow-tested by the Underwriters' Laboratories. Relief valves are set to start to discharge at a pressure between 100 and 125% of the design working pressure for A.S.M.E. U-68 and U-69 containers, between 90 and 100% of the design working pressure for A.S.M.E. U-200 and U-201 containers, and between 80 and 100% for A.P.I.-A.S.M.E. containers,

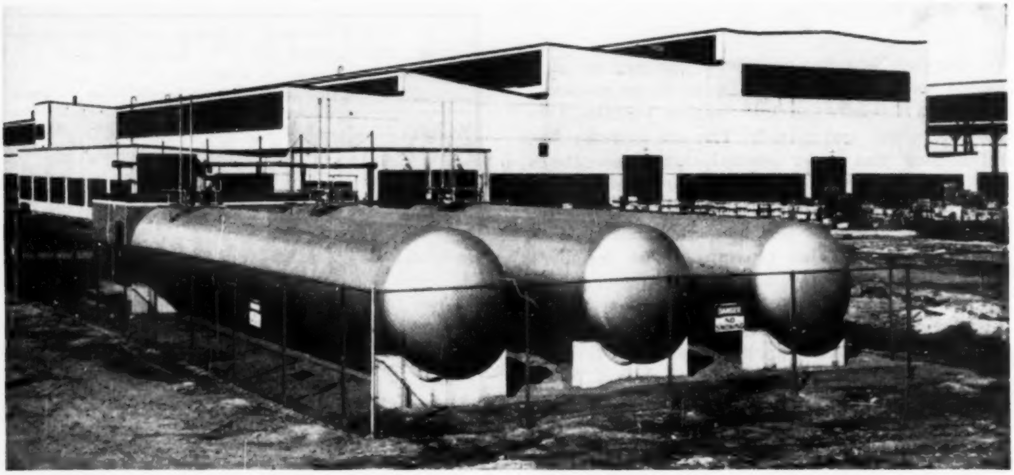
Table I — Characteristics of Fuel Gases

Gas	Boiling Point at Standard Pressure	Limits of Flammability (% Gas in Air)		
		Lower	Higher	Spread
Methane	−259° F.	5.00%	15.00%	10.00
Ethylene	−155	2.75	28.00	25.25
Ethane	−128	3.22	12.45	9.23
Propylene	−53.8	2.00	11.10	9.10
Propane	−43.7	2.37	9.50	6.13
Butylenes		1.70	9.00	7.30
Isobutane	+10.9	1.80	8.44	6.64
n-Butane	+31.1	1.86	8.41	6.55
Natural gas		4.80	14.60	9.80
Coal gas		5.60	30.8	25.2
Carbureted water gas		6.40	37.70	31.30
Carbon monoxide	−314	12.50	74.20	61.70
Hydrogen	−423	4.00	74.20	70.20
Benzene		1.41	6.75	5.34

Table II — Design Working Pressure and Classification of Storage Containers
(Pressures in Psi., Gage)

Container Type	Maximum Gaseous Pressure*	Minimum Design Working Pressure		
		A.S.M.E. Code U-68 U-69	A.S.M.E. Code U-200 U-201	A.P.I.-A.S.M.E. Code
100	100	100	113	125
125	125	125	141	156
150	150	150	169	187
175	175	175	197	219
200	200	200	225	250

*Vapor pressure of stored gases not to exceed this gage pressure at 100° F.



Liquefied petroleum gas (propane or butane) has long been used by the metal industry as a fuel—either primary or stand-by—and as controlled atmospheres for treating furnaces. When the storage, distribution and control system is properly engineered, undue hazards from large amounts of volatile combustibles are avoided. This brief account of safe practices by Mr. Mattocks will be of help to all who work around liquefied fuels—either as a check-list for periodic inspection, or as directions for emergency action after a human or mechanical failure has caused trouble.

and to secure the maximum required rate of flow at a pressure of 120% of the maximum permitted start-to-discharge pressure. Under this condition of maximum flow the minimum factor of safety in the joints of any vessel constructed according to these codes is never less than 3.3. Such setting of relief valves is in effect equivalent to setting the start-to-discharge pressure at less than the design working pressure for vessels constructed with a factor of safety of four.

It is necessary to use soft seats or soft sealing rings in relief valves to prevent leakage until the valve is called upon to open. Metal-to-metal seats might create a potential hazard from slight leakage which might develop especially after the valves have been in service for some time.

All openings in containers (except relief valves, gaging devices, and filling connections) are equipped with excess flow valves of the "slug" type. The slug or valve is held open against the direction of flow by a spring. When the flow past this slug is sufficient to create a pressure differential equal to or greater than the force of the spring, the flowing material closes the valve — in other words, it will close when the flow is less than the capacity of the line and fittings beyond it. Thus, if the line were ruptured, the escaping material would close the excess flow valve, thereby reducing the quantity of material lost to that contained within the broken line. A small drill hole in the slug permits gas pressure to build up on the downstream side until it is equivalent to the force of the spring, whereupon the valve will again open.

Before an installation is placed in service it is desirable to pressure the tank with air at 50 to 100 psi. While under this pressure the entire system should be tested for leaks. Likewise all the excess flow valves and the various regulators should be tested to insure their operation.

It does not appear necessary to remove the small amount of air remaining in the tank after the pressure is reduced to atmospheric. For example, take a 30,000-gal. tank full of air at atmospheric pressure. The first propane introduced into the tank will be completely vaporized. After

slightly less than 2 gal. of propane has entered, the lower limit of flammability would be reached — assuming the vapors were uniformly distributed throughout the tank. After approximately 11 gal. of liquid have entered (a matter of seconds), the upper flammable limit would have been exceeded. Although one can hardly imagine how this air-gas mixture inside the tank could become ignited, if it did, the resulting pressure generally would be insufficient to operate the relief valves.

Evaporation of Liquefied Petroleum Gas

The primary use of liquefied petroleum gas in industry is for fuel. Its major advantages are a high heating value and a high specific gravity. It may be withdrawn in vapor form from the top of the storage container, after which it is passed through the necessary regulating equipment to reduce the pressure to that desired. Since it is generally a mixture of several gases which boil at different temperatures, there is a tendency for the lower boiling point materials to vaporize first. The heating value of the gas initially withdrawn will therefore be somewhat different from the heating value of the gas withdrawn later.

When vapor is withdrawn from a partly-filled container it is replaced with vaporized liquid in the container. Change from liquid to vapor requires heat, and this is secured from the remaining liquid in the container, from the container walls, and eventually from the air surrounding the container. If vapor is withdrawn at too rapid a rate the pressure in the container may fall below a working pressure necessary to move the gas through the distribution system. Under such conditions, ice is likely to form on the outside of the tank; this indicates the high demand for heat to vaporize liquid. (Actually, the liquid temperature has been reduced below the freezing point of water.)

While the maximum desirable rate of vapor withdrawal from a storage tank depends upon the atmospheric conditions, the size and shape of the storage tank, and the quantity of material in the container, it is generally inadvisable to try to withdraw in any month more vapor than would come from a container full of liquid.

For large gas demands, or when the stored liquid petroleum gas consists of a mixture of gases, it is advisable to withdraw liquid as such and vaporize it in a separately heated vaporizer, heated by a separate medium such as steam or hot water. Proper precautions are necessary to prevent liquid from passing over into the gas system. Likewise, it is necessary to provide a separate relief valve for each vaporizer.

Fire Protection

Fire precautions are similar to those required for any other commercial gas. It should be remembered, however, that the gas (even when premixed with air) is heavier than air and seeks cellars or low spots in the terrain. Likewise, that its lower flammable limit is lower than for other commercial gases. It is possible, therefore, for the gas to hang closer to the floor and form a flammable mixture sooner than most other fuel gases.

If a gas leak develops, every effort should be made first to remove all sources of ignition within a reasonable distance. Next, dissipate the gas into the air by increasing the circulation.

If gas from a leak is ignited, the first major decision is to determine whether the fire should be extinguished or merely controlled. If it appears possible to stop the gas leakage by closing a valve, the fire may be extinguished in the minimum time. On the other hand, if it appears uncertain or doubtful that the source of leakage can be stopped, the fire may be controlled without attempting to extinguish it until the gas has been completely consumed. It should be remembered that, in general, a fire is controllable within certain limits while an explosion is not controllable and may result in a great deal more damage.

If a gas fire occurs near a liquid storage container the prime consideration should be to stop the leakage. If a fire from any cause is of sufficient magnitude to heat the tank, it is desirable to play water on the tank to keep it cool. Since the relief valves on a storage container will close when the pressure in the tank is reduced somewhat below the valves' popping pressure, no attempts should be made to extinguish any fire which might be burning at the outlet of the relief valve risers. Effort should be directed entirely to controlling the fire *around* the tank, since this is what causes the relief valves to operate.

It appears desirable to have first-aid fire extinguishers handy at all points where there is a possibility of leakage. First-aid fire extinguishers of the dry-powder type have certain advantages over the carbon dioxide type. Both, however, are very useful in controlling and extinguishing small fires. For large fires, water fog is probably best.

Years of experience have indicated that liquefied petroleum gas may be stored, handled and used with the utmost safety if proper engineering standards are adhered to and the precautions necessary to the handling of any fuel gas are taken. Evidence of this high degree of safety is given by the largely increased use of liquefied petroleum gas by industry in the past few years.

THE A.I.M.E.'s 1948 ELECTRIC FURNACE STEEL CONFERENCE

Any technical meeting which today brings together those interested in steelmaking generally includes in its program a discussion of metallurgical oxygen. This pattern was evident at the Sixth Annual Electric Furnace Steel Conference, sponsored by the Electric Furnace Steel Committee of the American Institute of Mining and Metallurgical Engineers, held at Pittsburgh early in December. Of special interest to the producers of steel castings by the acid electric process were sessions on the use of oxygen in steel melting and on the use of complex deoxidizers.

Oxygen in Steelmaking

Clyde H. Wyman, metallurgist for Burnside Steel Foundries, reported tests on 100 closely controlled heats made in a 5-ton furnace. Using injection periods of two to three minutes, 7.7 points of carbon were removed per minute when 50 cu.ft. of oxygen were introduced per minute by means of a lance. The over-all economies were reported to be \$0.99 per ton. R. H. Jacoby, metallurgist for the Key Co., and R. J. Wilcox, technical director of Michigan Steel Casting Co., likewise indicated a decided cost advantage connected with the use of the gas instead of ore for reducing carbon in the melt. The savings accrue from decreased power consumption, shorter heats, and conservation of ferro-alloys and deoxidizers. Added advantages are higher metal temperatures, better castability, and closer control of the whole operation. The most serious objection to the use of oxygen appears to be the heavy fumes produced; varying degrees of success in disposing of such smoke are being encountered.

Operators of basic furnaces had further information to report on the use of oxygen in the manufacture of stainless, alloy, and carbon grades. J. E. Harrod, assistant superintendent of electric furnaces for Carnegie-Illinois Steel Corp. in Chicago, cited the advantages of a greater use of stainless and high chromium scrap, better control of chromium analysis, and the elimination of rising ingots in stainless manufacture. In the manufacture of alloy and rimming grades, the use of oxygen resulted in faster carbon reduction, positive control of carbon content, greater recoveries of manganese and chromium, and improved rimming action. A. C. Ogan, assistant superintendent of electric furnaces for Carnegie-Illinois Steel Corp. in Duquesne, verified Mr. Harrod's results with data from his own shop and pointed out the effective use of the heat produced by oxygen injection in finishing heats by oxygen alone in the event of a sudden power failure.

On a more fundamental plane were papers by D. C. Hilty, research engineer for Union Carbide and Carbon Research Laboratories, and Dennis Carney and associates at Massachusetts Institute of Technology. The former presented an excellent experimental investigation of the relation between carbon and chromium in the refining of chromium steel. The study showed that the most probable reaction is

$$\text{CrO (saturated, in slag)} + \underline{\text{C}} = \underline{\text{Cr}} + \text{CO}$$

where $\underline{\text{C}}$ and $\underline{\text{Cr}}$ indicate that the elements are in solution in the iron. A wide range of compositions was investigated and the effect of temperature on

the reaction was determined; the preprinted paper must be consulted for details.

Mr. Carney's paper, "An Introduction to Gases in Steel", reviewed the effects of temperature, pressure, state of the metal, and alloying elements on the solubility of gases in metals. The effect of water vapor in increasing the solubility of hydrogen in metals (in a manner analogous to the introduction of nitrogen by ammonia) was treated thermodynamically. During the active discussion period, data, supported by quantitative hydrogen analyses, were presented by five or six speakers, which emphasized the deleterious effect of hydrogen content on the ductility of steels. (The lost ductility, fortunately, can be restored by aging treatments which eliminate hydrogen.)

Complex Deoxidizers

When is a deoxidizer complex? After some discussion the speakers agreed that a complex deoxidizer is one which contains two or more deoxidizing elements in significant quantities. What is a significant quantity? That a relatively small amount of deoxidizer can be significant was pointed out by G. A. Lillieqvist, research director of American Steel Foundries. For example, steel heats deoxidized with 99% silicon metal led to castings exhibiting a characteristic pinhole defect, whereas the same steels deoxidized with 75% ferrosilicon produced a sound product. This results from the fact that the ferro-alloy contains 1.5% of aluminum and thereby supplies about the amount needed to suppress gassiness. Mr. Lillieqvist also demonstrated that the rate of cooling of steels deoxidized with the normal amount of aluminum has a profound effect on the type of inclusion produced; a greater amount of the undesirable Type II inclusion is produced at faster cooling rates.

H. A. Young, of Crane Co., and E. Eubanks, chief metallurgist for Ohio Steel Foundry Co., found, after studies of various deoxidizers and mixtures of them, that no outstanding steel resulted from any particular prescription tested. Aluminum was always required to prevent pinholes; in other respects the *type* of deoxidation was unimportant as long as actual deoxidation resulted. John N. Ludwig, Jr., metallurgist for Electro Metal-

Photo by Henry M. Mayer

lurgical Co., in a paper primarily concerned with the calcium-containing deoxidizers, showed that calcium-silicon will reduce the oxygen content of steels to lower values than will 50% ferrosilicon, and that an important function of calcium-silicon is in changing the type of oxide inclusion from the stringer to a less harmful globular type. The apparent inconsistencies reported in the use of calcium-silicon are, in his opinion, caused by an insufficient study of the problem of determining modifications in practice necessary to produce consistently good results.

Safe Practices

A session on "Safety in the Melt Shop" featured papers by F. W. Brooke, vice-president of Swindell-Dressler Corp., W. F. Hitchcock, special engineer for Carnegie-Illinois Steel Corp., and R. C. Lake, of R. V. Cooper Co. Since secondary voltages have increased from 90 to 450 volts in the past few years, the electrical hazards associated with electric furnace operation have increased markedly. The tangible measures of protection, such as guards, protective clothing, inspection, and good housekeeping, are of great value in preventing accidents, but the important factor in safety is the intangible — education of personnel — which is often neglected.

The "Kellogg Process"

The progress that has been made by M. W. Kellogg Co. in the past few years in the development of machines for the production of composite materials and ingots by electric fusion was reviewed by R. K. Hopkins, manager of the firm's electric products department. After failures in attempts to produce clad metals by melting a number of alloy weld rods onto the surface of a carbon steel plate, a process was evolved in which electrodes of plain carbon steel wire are supplemented by tubular steel electrodes whose purpose is to produce the proper composition in the applied layer. By means of intricate metering devices ferro-alloys are fed through the tubular electrodes in the correct proportions. The sole purpose of the carbon steel electrodes is to fuse the surface of the carbon steel slab; this is done below a blanket of protective flux. The process is said to have great adaptability and is able to produce almost any desired analysis, the only limitation being that the cladding must be one carrying a reasonable amount of iron (since about 25% is picked up from the carbon steel slab). Many pressure vessels lined with austenitic alloys have been in service with no failure being attributed to any stress condition arising at the bonded alloy layer.

It was a natural step from a cladding process to the production of alloy steel ingots by electric fusion. The alloy making portion of the cladding process, when separated from the rest, contributes an ingot making method apparently having many advantages. The process is truly a continuous melting and casting method by means of which ingots of appropriate lengths can be produced. Since the ingots are literally pipeless, the entire weight can be used. An essential raw material is steel strip, supplied in coils, which is continuously formed into a tubular electrode through which the alloying elements may be added. As the electrode melts, the ingot mold is lowered slowly from the machine. The metal freezes at approximately the rate at which it is added, whereby ingots essentially free of primary and secondary pipe are produced.

Kellogg's electric hot-top process is a modification of the electric ingot process outlined above, and involves supplying heat at the top of metal teemed in an ingot mold, while the metal is covered with flux, to promote solidification of the teemed metal with a minimum formation of defects due to shrinkage. The heat is generated by discharge of electric current from the end of a nonconsumable electrode submerged in the flux. Attention was directed to the high yields obtained at a cost about the same as the operating cost using refractory hot tops.*

Elements of Steelmaking

The third annual Educational Series was devoted to the elementary principles in making an electric furnace heat. Two motion pictures presented by Allegheny Ludlum Steel Corp. portrayed the sequence of manufacturing operations, while the more important details of furnace care and maintenance, charging, testing, tapping and pouring were discussed by W. M. Farnsworth, assistant district manager of Republic Steel Corp. George E. Wagner, of Carnegie-Illinois Steel Corp., presented a detailed account of a method of calculating the charge for a stainless steel heat. The educational session was topped off by a question period during which queries were fired at a panel of experts, who, incidentally, proved themselves to be just that.

*Editor's Note — I quote "Critical Points" for January 1945, p. 108: "Unusually high solidification shrinkage in really dead melted monel metal ingots is counteracted by playing a single-phase arc on top the half-frozen ingot, thus producing a veritable hot top to feed the central pipe. Before this practice was instituted, more than a generation ago, the top discard would be 25%; now it is 5% or less."

A PROPOSAL FOR RESEARCH IN METALLURGY

By Michael G. Corson
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IT IS ALL TOO TRUE that many metallurgists labor under the basic assumption that research in metals must be "practical". That idea, if not inculcated into them at college, was acquired in the business organization to which they happen to belong.

Almost without exception, men in charge of industries have quite definite ideas in that direction. Money can be spent on research only when it can bring increased profits within a reasonable time. (Now and then they spend money on something that means plenty of fun, such as the construction of a 200-in. telescope.) On the other hand, who would consider studying intently a metal like silver? Our *precise* knowledge about it amounts to very little. We do not even know, accurately, how silver changes its dimensions from near the absolute zero to its melting point. But will anyone suggest that this problem should be studied at the expense of, let's say, \$20,000? Will it help to sell more silver at a better price? Will it be a lot of fun to see a carefully drawn diagram (and an equation describing the size changes) with a precision of 0.1%?

The answer is a definite NO.

The problem of the thermal expansion of silver was cited merely because it is a somewhat rare industrial metal. But I must go further and say that there is not a single metal in existence or use whose physical characteristics are accurately known — not even iron, whose American consumption amounts to far more than \$5 billion per year. Why? The same answer applies: More accurate physical data do not guarantee better steel, or more steel, or higher prices — hence cannot bring in any profits. As to fun — the man of business might get fun from looking at a streamlined train built of stainless steel, but never from an equation describing the electrical conductivity of iron at various temperatures. He must not be blamed; he is just built that way. Otherwise he could not be making money and so could not support such research anyway!

Consequently, I consider it justified to state that a systematic accumulation of scientific data and ideas — even about metals — must not be considered from the viewpoint of "practicality" or "fun". It may never bring back dollars and cents except by devious and obscure routes. It will never be as exciting as a football game. But the nation as a whole should spend in the task of scientific research many times more than it spends for exciting things. For what? Just for knowledge's sake! No other reason is needed, because, in the absence of that knowledge about metals, we shall never have a true metallurgical *science* — we must be content with a mere *art*.

The analytical reader may say, after he has read thus far, "These statements infer that the

present large expenditures for research by American industry are inadequate, and that the Government must supplement these spendings greatly." That is exactly the conclusion reached by the President's Scientific Research Board.* This group estimated that in 1947 the American expenditures for research and development were about as follows:

By industry	$450 million
By universities and others	85 million
By War Dept.	500 million
By other governmental departments (including nuclear research)	125 million
Total (of which 10% was classed as basic research)	$1160 million

The Board considered that this expenditure for research was insufficient in proportion to our national income and in view of the rapid advances in industry and science. It recommended that annual expenditures for research be increased, by Governmental appropriation and control, if necessary, until it equaled 1% of the national income by 1957 — roughly $2 billion for research, basic and industrial. It also recommended that expenditures for basic research be stepped up so that, by 1957, the *annual* investment would be $450 million. This, of course, would include basic researches into all the sciences, and thus give us a solid foundation for future advances, both in science and technical applications (industry). Of this $450 million annually one might assume that the science of metals might rightly ask for $20 million each year.

What can be done with $20,000,000 per year (or $200 million in a ten-year program)?

Getting Started

In order to start studying metals we must obtain a proper supply of them in the state of the highest purity, preferably of spectroscopic degree and at any rate not lower than 99.99%. Purity must not be chemical only. There should be no absorbed gases and no intergranular shrinkage.

In order to get such metals, we must build some large-scale laboratories — really pilot smelting and refining plants and loaning institutions — devoted strictly to *pure* metals. I think that at least three such institutions should be created, so that the same metal could be obtained from different sources. If one laboratory would fail to obtain the purity needed, another might do it. These laboratories should be parallel — not chain — institutions. Each should be able to produce in due time the needed amount of *any* metal desired.

What should be that amount? I think that, even in the case of a metal as expensive as platinum or iridium, at least two tons should be prepared. Such quantities are certainly available in a technically pure state. Purified they might cost $10 million for the platinum, perhaps $20 million for the iridium. Most metals will be much cheaper; a supply of ten tons of high-purity iron probably would not cost more than one or two million dollars. $100 million spread over a period of ten years will probably cover the expenses involved in getting the proper amounts of all metals than can be had at present.

Program of Research

Compressibility — Everyone who has come to grips with the problem of elasticity knows about the experimental difficulty of providing strictly unidirectional loading. It is strange, therefore, that only one American scientist, P. W. Bridgman of Harvard, has paid much attention to the alternative — namely, studying metal under a uniform (three-directional) pressure. A well-financed, comprehensive study could go far beyond Bridgman's achievements, both in degree of compression, purity of metals tested, and in accuracy.

Compressibilities must be determined with a high degree of precision — at least 0.1% correct — for four temperature points, such as −100° C., zero, +100 and 200° C. Such four points might permit us to extrapolate both up and down and to develop a reasonable idea of the magnitude of internal forces reigning in the lattices of metals and of their changes with temperature. This, in turn, will permit us to obtain the amount of stress induced by raising the temperature in different substances a single degree — for temperature is nothing else but stress.

Again I shall maintain that the task of the systematic study of compressibilities should not be confined to a single institution. At least three should operate continuously and independently. This is the only way to escape from the indefinite effects of human errors and foibles.

I have no accurate idea as to the cost of installation needed, and I surmise only that Professor Bridgman hardly spent as much as $300,000 during the 30-odd years he spent in the accumulation and analysis of his data. But I am certain that his apparatus could stand a lot of improvement and be greatly increased in size to yield a higher precision. Perhaps $1,000,000 per laboratory would equip each of them with the five or six experimental setups needed to do the work with substantial speed. An appropriation of

*See "Science and Public Policy — a Program for the Nation", a report to the President of the United States dated Aug. 27, 1947.

$2,000,000 or $3,000,000 for each, spread over a term of ten years, would undoubtedly cover all running expenses. In short, spending a total of about $12 million would suffice to acquire data on the compressibilities of the pure metals and probably of some selected alloys.

Specific Volumes — Few metallurgists and physicists are aware that our knowledge of specific gravities of the elementary metals is lamentably poor. Even for the common metals we do not know it with a precision much better than 0.3%. The specific gravity of iron is hardly known with a precision of 0.6%. It is also well known that the densities derived from direct weighing and from X-ray reflection spectras are never identical within the limits of experimental error. Furthermore, there is apparently a definite and monodirectional margin of 0.5 to 1.0% between densities measured on large samples by the displacement method and of very small samples weighed in the pycnometer.

These discrepancies may be the effects of surface forces, and one could hardly predict what basic information could be acquired by such comparative studies concerning the statistical average of lattice parameters in the shallow surface layers (X-ray densities), and the interatomic forces responsible for the discrepancies. The accurate study of specific gravity should also have a considerable effect upon our knowledge of the effects of plastic deformations. It is ordinarily assumed that the specific gravity hardly changes at all between the fully annealed and the heavily cold worked state. Here again a certain error of judgment has crept in, for a cube might be distorted into a prism without suffering much of a volume change. Therefore, the parallel study of gravities and of dimensional changes due to annealing might increase our knowledge about plastic distortion of the lattice. Laboratories to study these problems could also properly handle the next:

Thermal Expansion — Studying specific gravities (more exactly "specific volumes") would not entail a great expense. On the contrary the proper study of thermal expansions might be quite expensive. We have today fine instruments capable of producing rather precise data on wires through a considerable range of temperatures. Some cost about $4000. But they are by no means the acme of precision and their temperature ranges are not wide enough. Suppose that a proper instrument, operating in a neutral gas in any reasonable temperature range and permitting an extremely fine regulation, would cost $50,000. Suppose three laboratories equipped with ten setups each and a staff of 25 to 30 persons to supervise, run and record the data. The total cost of installation and running the three laboratories for acquiring data on specific gravity and thermal expansion might reach $8 million over a period of ten years.

Electrical Conductivities — Much of the data in this field is 50 years old. The researchers did not work with really pure materials, nor did they have the proper equipment and the proper help. Some of those old data are still of considerable value for the industry, but they are hopelessly antiquated for present-day science. Conductivities must be remeasured taking into account the effects of both pressure and temperature.

Three laboratories operating for the period of ten years might make a sweeping study of the problem of electrical conductivity from near absolute zero to the melting points of most metals, or at least up to 1000° C. Using machines duplicating those used for compressibility testing with certain modifications we might obtain the combined effects of pressure up to perhaps 100,000 kg. per sq.cm. and of temperatures from −100 to +200° C. The cost should not exceed $30 million.

Magnetic Susceptibilities — The problems are considerably more complicated in the realm of magnetic characteristics. Susceptibilities at ordinary temperatures and on standard samples might be readily found and rapidly completed. However, some characteristics are quite sensitive to shape and size, and they certainly are most sensitive to temperature. Besides, the experimentally obtainable values of susceptibility represent small fractions carrying very few valid digits, except for the magnetic metals and alloys. This field remains too obscure, and I shall merely mention the necessity of organizing a systematic investigation. I think that $3 million might cover the cost.

Work function is the energy required for the photo-electric removal of one electron from the atom on the surface of a given element. The fundamental requirements of the technique of measurement are reasonably well known; it is essentially a matter of finance to make the measurements under satisfactory conditions. The instruments needed require a high degree of refinement but are neither ponderous nor hard to operate. The study is most fascinating and could be done in a number of institutions at a modest expense. Three million dollars might suffice to equip ten laboratories properly for photoelectric studies and an analogous amount would keep them running for ten years.

Heat Content — In this field we compute the amount of heat change taking place within a certain range of temperatures. This change of heat content must be considered as balancing the energy changes occurring in all regions of the atom. Near the absolute zero, matter contains

no disposable heat and must stand in a specific equilibrium with the forces in and around it. Its characteristics at that point are the fundamental features. Above that point they undergo changes that should be expressible in the simplest manner as functions of the heat content.

All this goes to say that the precise determination of the heat content should form a substantial part of the fundamental research. It is rather unfortunate that hardly any systematic experimentation in that direction has taken place in the United States until these postwar years. It was being done in Holland, England and Canada, but rather sporadically, whenever a little money and some graduate students were available.

The difficulties besetting the research in the heat content are very great. No matter how rapid the operation, the temperatures of the body studied and of the calorimeter suffer unavoidable extraneous changes so that neither of the measured temperatures is likely to be true to 0.1%. On the other hand, the heat content must be known with a precision of at least 0.01% if we wish to obtain a reliable functional relationship between it and the other characteristics of matter.

We may rest sure, however, that our men of science and technicians can find the proper methods if given a chance. I think that if we grant $50,000 for the construction of each calorimetric setup the problem will be solved. And again, three specialized institutions each equipped with five to ten such sets and working for ten years could produce all the data which might be used. Five to six million dollars would cover the expenses of that work.

Electrochemical and Contact Potentials — Quite ticklish, but fortunately no extreme precision will be needed because both features are *surface* characteristics. A precision of 0.1% might easily be satisfactory. The setups cannot be very costly and the work could be quite rapid. I would estimate that the expenditure of $1,000,000 in ten years or earlier (as soon as the purified metals are available even in small quantities) should produce all the data needed.

Monodirectional and bidirectional stress is the last item in the program. The problem is how to organize the examination of metals in plain tension (and in plain tension plus internal pressure) so as to obtain something better than crude approximations. The minimum diameter of test bar for such scientific work should be about 4 in. with a 10-in. gage length. At least three high-precision recording tensometers should be used to register elastic elongations and three others for the elastic contraction. At least two photographic recorders should be used to register the deformations occurring in the plastic range. Provision should be made for accurate study at temperatures considerably above and below the ambient. Hollow specimens of the same outside diameter and 3 in. inside diameter could be used to examine the effects of the radial pressure.

That's why I suggest that the purifying laboratories should be capable of preparing on a large scale (one or two tons at least) even such expensive metals as platinum and iridium. Of course, such metals need not be scrapped — merely loaned until the particular investigation is completed.

Machines that could be used for tensile experiments already exist. The load capacities will run up to 1,000,000 lb. The measuring instruments, however, must still be developed. But, the principles being known, the task could not be difficult. Thirty setups distributed between three laboratories would cost about $6 million and the cost of running them for ten years should not go above $24 million.

The Total Cost

While these figures are not taken from the blue sky, they cannot pretend to indicate more than the order of the magnitudes involved:

1.	Preparation of large amounts of purified metals (about 70 items) in three or more specific physical states	$100 million
2.	Compressibility research	12 million
3.	Specific gravity and thermal expansion	8 million
4.	Electrical conductivity	30 million
5.	Thermal conductivity	2 million
6.	Magnetic susceptibility	3 million
7.	Photo-electric effect	6 million
8.	Heat content	6 million
9.	Electrochemical and contact potentials	1 million
10.	Monodirectional and bidirectional stressing, plus plasticity	30 million
	Total cost about	$200 million

Of this amount one third probably would have to be spent on instrumental equipment at the start; the balance will be spent at the rate of $13 million per year.

These figures might seem outrageous. Normally a metallurgist has quite a time explaining to the treasurer why he needs a microscope and auxiliaries at a cost of $5000 and a spectrograph at $8000. If we bear in mind, however, the reasoned conclusion of the Research Board mentioned earlier that $2 billion should be spent on research *every year*, a matter of $20 million should not be too much to appropriate for the study of these metallic materials, so important to our well-being.

CORRESPONDENCE

The Designation of Phases in Alloy Systems

PHILADELPHIA

To the Readers of METAL PROGRESS:

While attending the recent presentation and discussion of a paper devoted to the phase diagram of the cobalt-chromium system, I was impressed with the desirability of standardizing the designations of phases in all alloy phase diagrams. In the cobalt-chromium system, for example, there is a compound Co_2Cr_3 to which the designation γ is given. This phase has a crystal structure identical with, and physical properties similar to, the FeCr phase in the iron-chromium system, to which the designation σ has been given. In the iron-vanadium system, this same crystalline phase is designated ϵ. Such useless disagreement appears among systems too numerous and well known to require detailing here. If the phase designations were standardized according to crystalline form, it would be a long step toward clarification.

Apparently the nearest approach to a system has been that of designating phases consecutively from left to right with letters of the Greek alphabet. The convenience and desirability of a uniform system of designations based on structure is obvious. The practicability of such standardization would depend on the willingness of those interested to cooperate. It is recognized that it would take a long time, if a change were made, to educate metallurgists to abandon familiar terms such as β-brass and α-iron. The transition need not involve such steps. Were a table of standard designations adopted, such designations could appear between parentheses after the ones customarily used. The new designations need not be Greek letters. They could be Arabic or Roman numerals, or English letters. Idealized, the suggestion results in a table of three columns, the first giving the standard designation, the second its crystal structure, and the third its typical X-ray diffraction pattern. Phases having the same crystal structure would then be identified as α (I) in one diagram and, for example, γ (I) in another, or α *(a)* in one and γ *(a)* in another, and so on. This suggestion is perhaps oversimplified. But however complicated a system might result — and it is difficult to imagine a very complicated one — it would be an improvement on the present lack of system.

The writer proposes the formation of an international committee, composed of representatives of the interested technical societies, to undertake this work. The nucleus of this committee could be the A.S.M. Phase Diagram Committee, which was responsible for the compilation of diagrams in the 1948 edition of the "Metals Handbook".

FRANCIS B. FOLEY
Chief Research Engineer
The Midvale Co.

EDITOR'S NOTE: In the article on p. 62 of this issue, there is further discussion about naming the phases in alloy systems.

Calibration of Testing Machines With a Proving Ring

OTTAWA, ONT.

To the Readers of METAL PROGRESS:

I was interested to read, in the September issue of *Metal Progress*, D. H. Rowland's description of a method to facilitate the use of a proving ring under conditions where the general noise level is unduly high. The method suggested employs a contact microphone, audio amplifier, and head phones, in order to render more precise the detection of the correct buzzing intensity of the vibrating reed. The same result may be achieved conveniently by the use of a standard medical stethoscope. The input end of this instrument can be held in contact with, or can be attached to, the body of the proving ring or a platen of the testing machine, and the definition obtained is very good.

The simplicity of this method is an obvious

advantage. I have seen it used successfully in industrial machine shops where the noise level was so high as to make oral communication difficult.

R. C. A. THURSTON
Metallurgical Engineer
Canadian Bureau of Mines

MUNHALL, PA.

To the Readers of METAL PROGRESS:

D. H. Rowland has presented a valuable adjunct to the use of proving rings. A suggestion is offered here that would add to the use of his device. In the calibration of testing machines it is extremely difficult to follow, by manipulation of the micrometer, the slightly increasing load of the testing machine. Unless one has developed a "feel", the tendency is either to lag or exceed the changing deformation of the ring, so that the end point is difficult to reproduce precisely. The attachment of an auxiliary thumb screw by means of a friction drive to the micrometer would greatly facilitate this important part of the technique. One type of ring requires the operator to estimate tenths of a division, thus providing another source of error. The use of an index with such a screw would eliminate this variable.

SAMUEL GOLDBERG
Associate Metallurgist
U. S. Navy Metals Laboratory

Alloying Elements in Steel — 1891

CHICAGO

To the Readers of METAL PROGRESS:

In connection with the articles on the development of alloy steel, published in the October issue of *Metal Progress*, it may be interesting to read some statements written 58 years ago by A. Bosmaer in his book "The Mechanical and Other Properties of Iron and Steel" (E. and F. N. Spon, London, 1891).

The rest of this letter is a verbatim copy of Bosmaer's text; the errors in grammar and spelling were in the original.

ALUMINUM IN STEEL — The most important property of aluminum is its lowering the melting point of steel considerably; as yet this seems to be the only advantage of it, and even this is not made use of, on account of the high price of aluminum. Its use for steel making will remain what it is, i.e., practically not at all, unless its price becomes reduced to, at most, a tenth of what it is at present, or unless some remarkable property is discovered. Though more than one has tried to introduce aluminum for the manufacture of steel without blowholes, we doubt whether anyone will have success with it.

Neither does aluminum decompose iron oxides, nor does Al_2O_3 form easily fusible compounds with iron-manganese or silicon oxide.

If it be true that 0.1 per cent aluminum lowers the melting point some 250° C., this would be a very useful property in dealing with chromium steels, tungsten steels, etc., but if this is not true we do not see any use for aluminum.

COBALT — The metallurgical behavior of cobalt is quite similar to that of nickel, it being easily reduced, but oxidized with difficulty.

The quantities of cobalt present in some ores is too little to give more than slight traces in the pig, and cobalt ores are too dear to be used purposely.

Iron and cobalt unite easily. Bottons of 53 and 13 per cent cobalt proved to be well molten, but not malleable. Alloys of cobalt with iron are said to be strongly magnetic.

The price of cobalt being about ten times that of nickel, there will be hardly reason for experimenting with it, since an influence on steel different from that of nickel cannot be expected.

MOLYBDENUM — Molybdenum is occasionally present in iron ores (Swedish ores); it has a particular affinity for silican and alumina, hence the whole of it will be found in the cinder. Impure alloys of molybdenum and iron have shown great resemblance to tungsten steels, but the pure metal being very costly there is little hope of its application.

TITANIUM — Although Mushet himself was thoroughly convinced of the beneficial effect of titanium on steel and iron that he took out 13 patents to protect his invention; although others affirm titanium steel to be harder, stronger, and more ductile than other steel, titanium steel has not yet succeeded in making its way, and it is doubtful whether it will do so.

THOMAS S. SIMMS
Research Consultant in Metallurgy
The John Crerar Library

New Type of Metallurgical Microscope

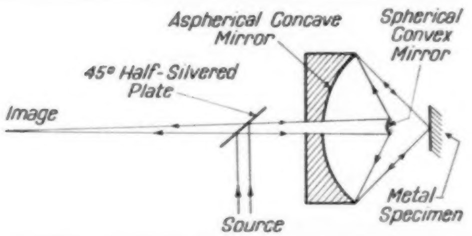
LONDON, ENGLAND

To the Readers of METAL PROGRESS:

Photomicrographs at 500 diameters of metal surfaces at a bright red heat have been obtained successfully at Bristol University, England, utilizing a reflecting microscope. In this instrument, concave and convex mirrors take the place of the conventional lenses. The technique was developed recently by C. R. Burch and K. W. Keohane, although the possibility of using a mirror pair as a microscope objective has been recognized for many years. [The optical system is indicated by the cut in the next column.]

It was known that if spherical mirrors were used, a poor quality image was obtained unless one was content with a low numerical aperture and a large obstruction ratio. (The term "obstruction ratio" refers to the proportion of the large mirror

that is necessarily obstructed by the small mirror.) In the early part of this century, a German, Schwartzchild, obtained solutions to equations for aplanatic telescope systems. Burch applied these solutions to the design of an aplanatic microscope objective, and he has since constructed a number of such objectives. This has necessitated the development of methods of aspherizing one or both of the components of the mirror pair. He has shown that for apertures up to 0.65 N.A. it is permissible to have one of the mirrors spherical; from considerations of ease of aspherizing, it is usual



Optical System for Reflecting Microscope

to keep the convex mirror spherical and to make the concave mirror aspherical by about 80 fringes.

Because there is no dispersion with reflection, the instrument is free from chromatic aberration. Therefore the instrument can be used for photography in the ultraviolet spectrum (thus increasing the resolving power and obtaining selective absorption) after focusing in visible light. Another advantage is the comparatively long working distance — about 1.5 cm. for 0.7 N.A. The depth of focus is the same as for a refracting microscope of equal numerical aperture; this property depends only on the wave length of the illuminating light.

An important metallurgical application arises from the long working distance, as it facilitates the examination of hot metal surfaces at high magnification (about 700× with the 0.65 N.A. objective). As a demonstration of this application, photographs have been taken in Bristol of the surfaces of metals such as nickel, steel and molybdenum, at various temperatures up to bright red heat. Higher temperatures could have been attained with better arrangements for heating the specimen.

The mirrors used are of aluminized speculum metal. An attempt is to be made to build a reflecting microscope having a numerical aperture of 0.98.

TOM BISHOP
Metallurgical Editor
The Iron & Coal Trades Review

Fourtomicrographs

KOKOMO, IND.

To the Readers of METAL PROGRESS:

During a recent metallographic examination of hard facing weld deposits, tungsten carbide in the form of a number was observed imbedded in the stellite matrix of our special composite-rod deposit, as shown in the accompanying micro.

The specimen was etched electrolytically in a 2% solution of chromic acid, and was then stained by an alkaline permanganate solution. The magnification is 500×.

W. F. BERTRAM
Metallographer
Haynes Stellite Co.

GOTHENBURG, SWEDEN

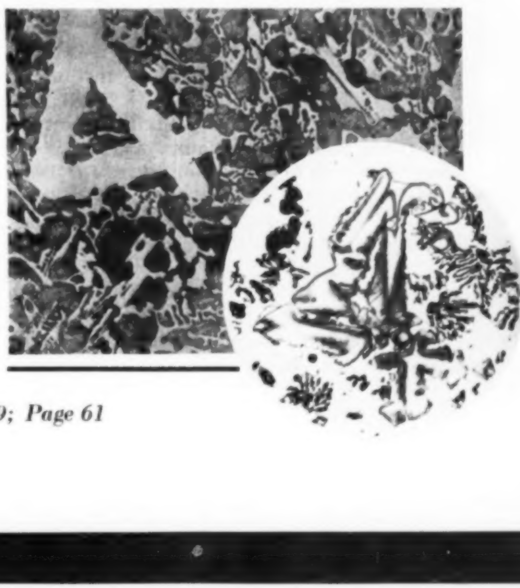
To the Readers of METAL PROGRESS:

The accompanying micrograph shows a numeral 4 in the structure of a hard facing weld metal of the stellite type. This alloy contains about 4.5% C, 19% Cr, 40% W, 27.5% Co, 1.5% Cb, the rest iron. The specimen was etched in Vilella's reagent [5 cc. hydrochloric acid and 1 g. picric acid dissolved in 100 cc. ethyl or methyl alcohol] and then photographed at 2000×. The numeral and other white portions are tungsten carbides.

TORE NOREN
Head of the Metallographic Laboratory
Electric Welding Association

EDITOR'S NOTE: In addition to its valuable chemical and mechanical characteristics, this alloy apparently has interesting "numerical" properties. Metallurgists and numerologists alike may ponder the higher usefulness of a metal that counts to four.

Fourtomicrographs of Stellite. (Left) Swedish, (right) American



THE DESIGNATION OF PHASES IN ALLOY SYSTEMS

By Taylor Lyman
Associate Editor, Metal Progress
Editor, Metals Handbook

THE NAMES AND DESIGNATIONS of alloys are a problem. The problem is to remember them. Perhaps one of the Quiz Kids could do it in his unaided head, but most metallurgists and engineers require a shelf of reference books and catalogs to keep the 10,000 alloy names in order.

However euphonious current trade names may be, many of them have no logical relation with the thing being named. We might suppose that in the *science* of metals, untainted by the brush of commercialism, names would be more meaningful. But, actually, it is in the sciences that nomenclature has reached the highest form of abstruseness — pure, random symbolism. In the Correspondence columns of this issue, p. 59, Francis Foley raises a basic question about the designation of phases in alloy systems. Gently and with utmost restraint, Mr. Foley considers that the present lack of systematic terminology is an abomination. Everyone can agree on that!

The question of phase terminology has been discussed intermittently for about 20 years. Much of the published discussion has appeared as letters to the Editor of the *Journal* of the Institute of Metals (for instance, February 1937, April 1937, February 1942, and July 1947). During the years 1941 to 1947 phase nomenclature was considered in detail by the ⊕ Committee on Phase Diagrams, which supervised the preparation of the diagrams in the 1948 "Metals Handbook". (See, for instance, John Marsh's letter in *Metal Progress* for January 1942.) The purpose of this article is to review the ideas currently in circulation and the difficulties that have prevented general agreement.

There are two methods of phase designation logical and extensive enough to be called systematic. One of these has been developed gradually in England during the last 20 years; the other, in America during the same period. Both have been applied to a restricted group of nonferrous alloys. Neither is free from objections. Each is based on a fundamentally different idea. Either could be expanded into a general system.

In the system originally proposed by Bradley in England, phases of the same crystal structure are denoted by the same Greek letter in all diagrams containing a phase of that structure. Hume-Rothery has used this system extensively in his writings on the equilibrium diagrams of copper, silver and gold alloys, in which the Greek letters α, β, β', γ, ε, ζ, ζ' and μ are applied systematically to phases having eight different structures encountered repeatedly in the alloys studied.

One difficulty in extending this system to *all* phase diagrams is that the body-centered cubic and face-centered cubic modifications of iron have always been denoted alpha and gamma, respectively, whereas in copper, silver and gold alloys, alpha is used for the face-centered cube, beta for the body-centered cube and gamma for the complex structure characteristic of gamma brass. As yet, no compromise has made this system of terminology generally acceptable to both ferrous and nonferrous metallurgists. The addition of subscripts to α and γ when they are used to designate terminal solutions might provide a basis for eventual agreement. Subscripts might be used also in diagrams that contain several phases having the same crystal structure.

Another difficulty is how to designate phases

Those readers (irrespective of occupation) who believe that people can work together in harmony and understanding will be interested in ⊕ Past-President Foley's suggestion on p. 59 that an international committee be formed to bring some order to terminology in phase diagrams. The secretary of the ⊕ Committee on Phase Diagrams, which considered the question of terminology when they were planning the diagrams reproduced in the "Metals Handbook", reviews here some of the difficulties that have prevented a consistent nomenclature.

whose crystal structures have not yet been determined. Perhaps upper-case English letters might be used temporarily to designate such phases until the crystal structures have been determined and Greek letters assigned. Phases of undetermined structure that are known to occur in several systems (for instance, the sigma phases mentioned by Mr. Foley) could be assigned a Greek letter and given a subscript x to indicate that the structure has not been completely determined.

In diagrams from the Aluminum Research Laboratories in this country, a system of nomenclature based on chemical composition has been used. In addition to its application to phase diagrams, the Alcoa notation is used on micrographs, in tables of etching reagents, and in other charts listing the properties of constituents in commercial aluminum alloys.

(The next two paragraphs are from the explanation of the Alcoa system by W. L. Fink on p. 4 and 5 of a book "Physical Metallurgy of Aluminum", to be published this month by the American Society for Metals.)

In the Alcoa system, the designation of a phase consists of the chemical symbols of the elements necessary for the formation of that phase. The symbols are enclosed in parentheses, in the order of decreasing atomic percentages of the elements. The symbols are separated by hyphens in order to distinguish them from chemical formulas. For example, the intermetallic compound [often called $CuAl_2$ or θ] that occurs at the aluminum end of the aluminum-copper system is designated (Al-Cu). Elements that are not necessary to the formation of the phase but which may be present in solid solution are not indicated in the designation. For example, the solid solution occurring at the aluminum end of any binary system or at the aluminum corner of any ternary system is indicated as (Al).

If two or more phases would have the same designation according to the above rules, they are distinguished by prefixing Greek letters. For example, in the binary aluminum-nickel system shown in Fig. 1, the two intermediate phases containing more atoms of aluminum than of nickel are designated α(Al-Ni) and β(Al-Ni). Similarly, the nickel-rich intermediate phase is designated α(Ni-Al). The phase in the middle of the aluminum-nickel diagram is β(Ni-Al) rather than γ(Al-Ni) because the phase field extends farther toward the nickel end.

Designations based on composition are not new. From the very beginning of alloy science, certain intermediate phases have been designated by chemical formulas. For instance, the phases called α(Al-Ni) and β(Al-Ni) in Fig. 1 were long known as $NiAl_3$ and $NiAl_2$, respectively. ($NiAl_3$ is still a

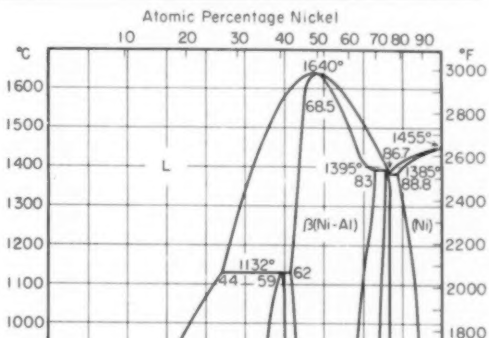


Fig. 1 — Phase Diagram for the Aluminum-Nickel System, Showing Alcoa Phase Designations

common designation.) As knowledge increased, it became apparent that many of the phases which were being designated by formulas actually existed over a range of composition. To cite an extreme example, the phase usually referred to as $Mg_3Zn_3Al_2$ extends halfway across the ternary diagram (from 20 to 70% zinc), whereas the formula indicates one definite composition. Furthermore, the range of composition of a phase sometimes does not include the single composition referred to by the formula. For example, β(Al-Ni) in Fig. 1 does not include the composition $NiAl_2$. Chemical formulas are now used less frequently than before in alloy nomenclature. However, formulas are still widely used for designating alloy phases that are similar to chemical compounds in their narrow range of homogeneity — for instance, Fe_3C, Mg_2Si and Cu_3P. These formulas tell more about the chemical compositions of the phases than designations such as α(Fe-C), α(Mg-Si) and α(Cu-P). Formulas are especially helpful when the phase diagram is not at hand.

The Alcoa notations avoid the disadvantages of chemical formulas while retaining composition as the basis for the designations. However, in all likelihood, the Alcoa designations would be unsatisfactory to those who, like Messrs. Foley, Bradley, and Hume-Rothery, prefer a nomenclature based on structure. In addition to this fundamental objection, there might also be some question concerning practicability.

In a binary alloy system with many intermediate phases (the copper-aluminum system, for example) the reader is not helped greatly by the multiple repetition of the chemical symbols (Cu-Al). The reader knows that each phase contains both copper and aluminum, without being confronted by the symbols (Cu-Al) 12 times in 4 sq.in., but according to the Alcoa system the symbols must be included as a part of the designation for each of the 12 intermediate phases. It seems fair to ask whether, in binary systems, these repetitious chemical symbols earn their way in terms of services rendered.

In his letter on page 59, Mr. Foley mentions that the practicability of standardization would depend on the willingness of those interested to cooperate. But "there's many a slip 'twixt the cup and the lip". It might be interesting to review how extensively some other efforts at standardization of letter symbols have been accepted. (This is no small subject; a recent book "Scientific and Technical Abbreviations, Signs and Symbols" extends to 476 pages.)

In 1932, the American Standards Association adopted a standard on Abbreviations for Scientific and Engineering Terms (A.S.A. Z10.1). Yet today, 17 years later, many writers ignore the standard and many editors are still laboriously "correcting" standard abbreviations to nonstandard forms in order to make the copy consistent with their individual style sheets. The force of habit is powerful and is not overcome by logic alone.

Chemists seem to have been more successful than other scientists in solving problems of nomenclature, although outstanding inconsistencies still remain, even at the elementary level — for instance, columbium versus niobium, Be versus Gl, and, of course, aluminum versus aluminium.

The acceptability of a standard is probably related closely to the composition of the authoritative committee. Who, then, should comprise the committee that would have the last unquestionable Word on the subject of phase designations? Mr. Foley and others have suggested that these problems ought to be considered by an international group. The statistics of Fig. 2 support this view. (These data were compiled from the starred citations in Haughton's "Bibliography of the Literature Relating to Constitutional Diagrams of Alloys".) The production of phase diagrams has indeed been international, though largely in the sense that several other countries have helped the Germans and the British in this basic research. (The strong preponderance of German publications on phase diagrams suggests one further query: Who will do this fundamental research now that German science is so largely impoverished? This query is probably worth more consideration than the main subject being discussed here — that is, nomenclature, a matter of form, not of substance.)

International conferences have become common in science and engineering. The science of metals might make a small but useful contribution to international understanding through an International Committee on Phase Diagrams.

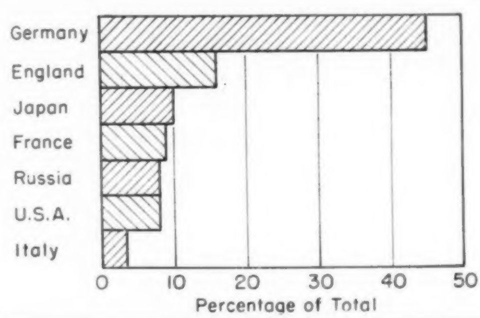


Fig. 2 — Origin of Phase Diagrams by Countries

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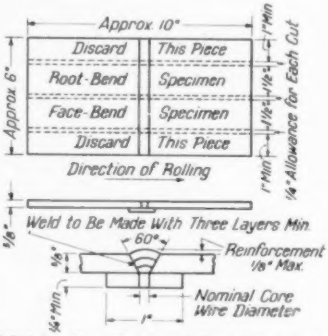
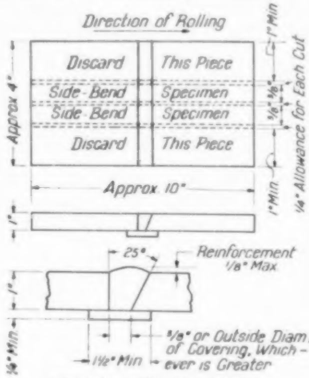
Mechanical Testing of Arc Welds

From Joint Specifications of American Welding Society and American Society for Testing Materials

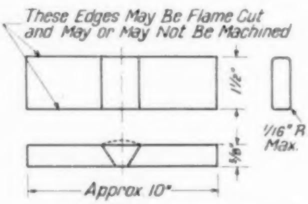


Joint for Face-Bend and Root-Bend Tests

Some or all of the specimens shown here are described in the specifications for each of the following types of arc welding electrodes: mild steel (A.W.S. A5.1-48T, A.S.T.M. A233-48T), low-alloy steel (A.W.S. A5.5-48T, A.S.T.M. A316-48T), corrosion resisting chromium and chromium-nickel steel (A.W.S. A5.4-48T, A.S.T.M. A298-48T), and copper and copper alloy (A.W.S. A5.6-48T, A.S.T.M. B225-48T). These specifications include chemical and mechanical requirements, coatings, current requirements and welding positions for many classifications of electrodes made of the four types of material mentioned.

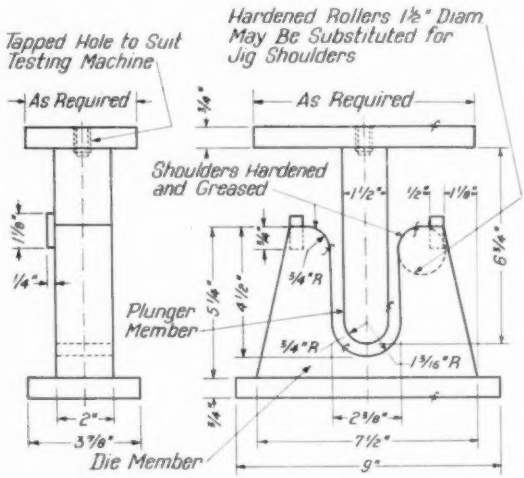


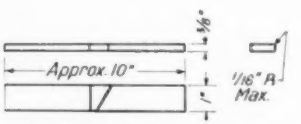
Joint for Side-Bend Test



Weld reinforcement and backing strip shall be removed flush with the surface of the specimen. Machining or grinding shall be done lengthwise on the specimen. The test surface shall be finely machined or ground.

Face-Bend and Root-Bend Specimens



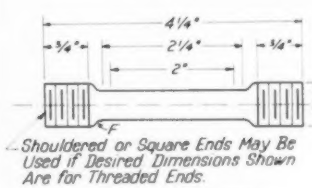


Specimens shall be sawed or machined from the test joint. Weld reinforcement and backing strip shall be removed flush with the surface of the specimen. Machining or grinding shall be done lengthwise on specimen. The surface of specimen to be tested shall be finely machined or ground.

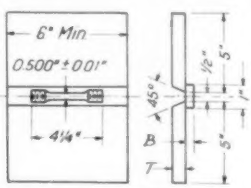
Side-Bend Specimen

Face-bend specimens are placed with the face of the weld directed toward the gap; root-bend specimens are placed with the root of the weld directed toward the gap; side-bend specimens are placed with the side showing the greater defects, if any, directed toward the gap. The two members of the jig are then forced together until the specimen conforms to a U-shape, and until a wire 1/32 in. in diameter cannot be placed between specimen and plunger.

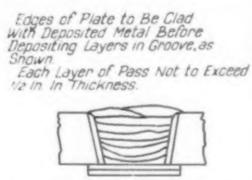
Jig for Face-Bend, Root-Bend and Side-Bend Tests



Tensile Test Specimen

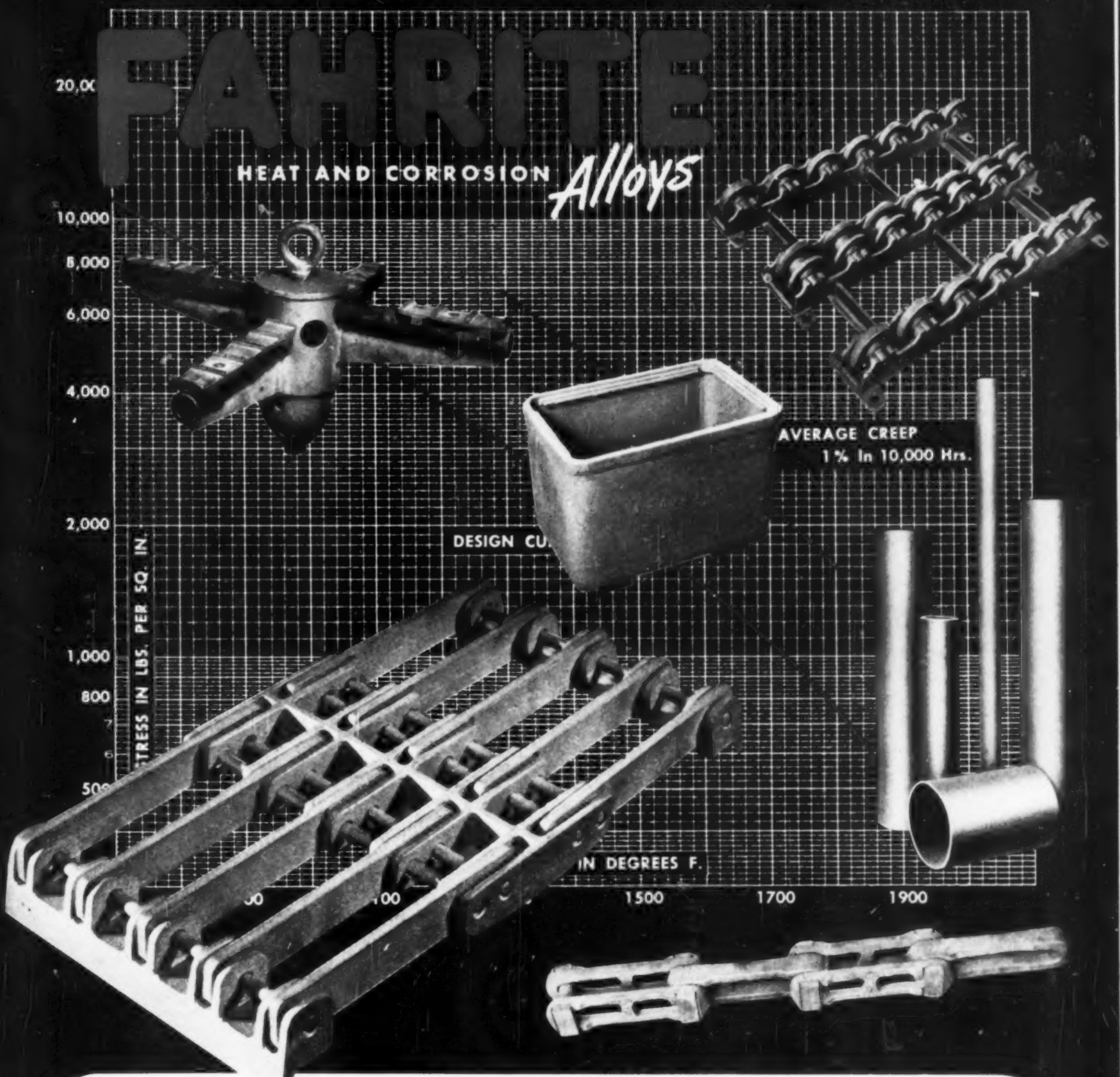


Location of Specimen in Plate

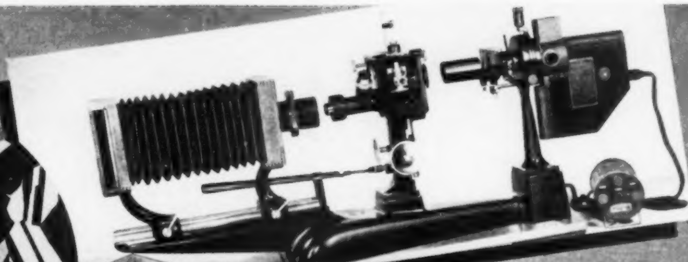


Type of Deposited Layers

Requirements for the Preparation of All-Weld-Metal Tensile Test Specimens


FAHRITE
HEAT AND CORROSION Alloys
20,00
10,000
8,000
6,000
4,000
2,000
1,000
800
AVERAGE CREEP
1% In 10,000 Hrs.
DESIGN CU
TRESS IN LBS. PER SQ. IN.
IN DEGREES F.
1500
1700
1900

PHOTOMICROGRAPH OF CARTRIDGE BRASS TAKEN ON RESEARCH METALLOGRAPH



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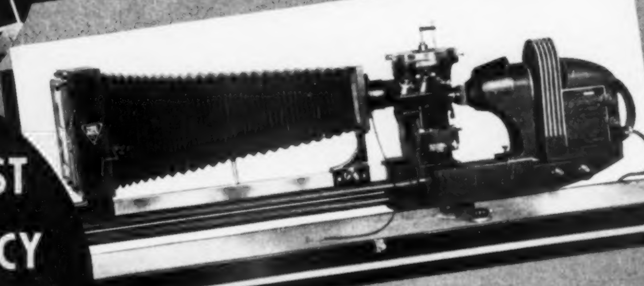

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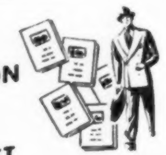


MARTEMPERING

By R. H. Aborn
Assistant Director
Research Laboratory
United States Steel Corp
Kearny, N. J.

ONLY A FEW YEARS AGO the heat treatment of steel was strictly an art, but recently it has shown definite progress toward becoming a science. This transformation, like most advances in technology, is a process of nucleation and growth of ideas arising from our increasing knowledge. One direct result of basic metallurgical knowledge has been the development of the heat treatment known as martempering. The aim of this article is to show the application of some recent research to the process of martempering carbon and low-alloy steels.

During the martempering of steel, austenite transforms to martensite under controlled conditions. It may be appropriate, therefore, to review briefly the salient characteristics of the austenite-to-martensite transformation.

The purpose of quenching steel is to harden it — but more is involved than hardening. The piece should come out whole and not cracked or distorted. An ideal quenching medium would cool the steel very fast above 900° F. and very slowly through the martensite range. No such quenching medium exists. However, martempering comes closer than other quenching processes, and is being used increasingly for heat treating parts that must have less residual stress and distortion than result from an oil quench. This article discusses the limitations and results of martempering carbon and low-alloy steels. It includes specific information about distortion, cracking, and the maximum size of bar that can be hardened by martempering.

Martensite forms almost instantaneously while austenite is being cooled. If the cooling is interrupted, the transformation stops. Only a further decrease in temperature, or plastic deformation, will induce a resumption of the transformation. The formation of martensite is essentially timeless and is generally believed to occur without nucleation, growth or diffusion. Moreover, martensite forms only when the steel is cooled below a certain temperature, called the M_s temperature, which depends on the chemical composition of the austenite. If the M_s temperature is high, or the cooling not drastic, martensite undergoes self-tempering during cooling; the extent of such tempering increases as the rate of cooling decreases.

To reach the lower-temperature zone where martensite can form, austenite must be cooled fast enough so that it will not transform into ferrite, pearlite or bainite at temperatures above M_s. The rate which is just fast enough to avoid formation of these products is called the critical cooling velocity. Transformation to these undesired products requires an incubation period, which varies enormously with composition, so that the critical cooling velocity to retain austenite intact to the martensite range varies from more than 9000° F. per sec. in low-carbon steel to much less than 1° F. per sec. in some of the high-alloy steels.

The drastic cooling required in carbon and low-alloy steels to obtain a fully martensitic structure generally causes high residual stress and distortion, which may be so pronounced that the steel will crack during the quench.

The ideal method of minimizing these undesirable characteristics is to cool the steel fast enough to retain all the austenite at the M_s temperature, to allow full equalization of temperature at or just above M_s, and then to cool very slowly through the range of martensite formation. By this means the thermal gradient and resulting stresses can be dissipated while the steel is still in the soft austenitic condition at M_s. The transformation stresses and the supersaturation with carbon can be reduced to the extent that self-tempering occurs in the retarded cooling below M_s.

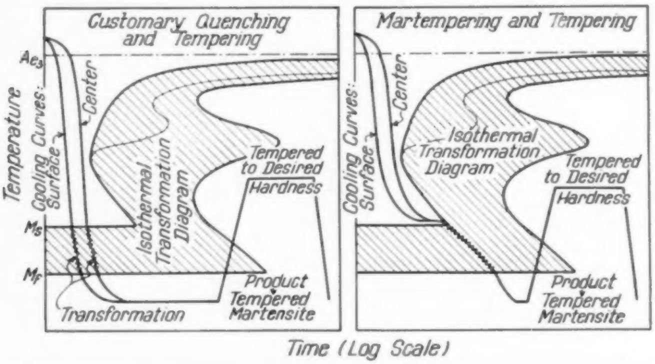


Fig. 1 — Time-Temperature Relations in Customary Quenching and Tempering and in Martempering and Tempering

This is the principle of the process discovered by D. Lewis in England, in 1929, and recently developed and popularized under the name of martempering by B. F. Shepherd. Figure 1 shows schematically how martempering and tempering differs from conventional quenching and tempering. In each process it is assumed that the composition and section size of the steel are such that the austenite can transform entirely to martensite. In the conventional process martensite forms during continuous drastic cooling, whereas in ideal martempering there are three steps in hardening: *(a)* rapid cooling to the M_s temperature, *(b)* equalization of temperature throughout the heat treated part at that temperature level, and *(c)* retarded cooling through the range of temperature in which martensite forms.* The effectiveness of the cooling to the M_s temperature to maintain the austenite untransformed, depends on the prior austenitizing conditions as well as on the conditions of cooling.

Effect of Austenitizing Conditions

An austenitizing atmosphere that minimizes oxidation of both iron and carbon is one of the most important factors because scale is a barrier to heat removal in quenching and because lower carbon content in a hypo-eutectoid steel makes austenite more likely to transform above M_s. For any given composition and initial structure, the austenitizing temperature selected determines the austenitic grain size and the extent of carbide solution and homogenization of the austenite. The coarser the grain or the greater the carbide solution and homogenization of austenite, the more stable is the austenite, and the larger the section that can be fully hardened. However, this increased hardenability may be partly or wholly offset by reduced toughness from the coarser grain size, by greater tendency to oxidize in the furnace at the higher austenitizing temperature and between the furnace and the quenching bath, and by somewhat slower cooling because of the greater amount of heat to be removed.

Effect of Cooling Conditions Above Ms

The process of cooling at any point within a metal being quenched involves: *(a)* heat flow to the surface by conduction, *(b)* transfer of this heat to the quenching medium and *(c)* dissipation of the heat by the quenching medium. The cooling rate at any point within the metal depends on the size and shape of the piece, the thermal diffusivity

*The term martempering is sometimes applied to treatments in which transformation is substantially completed before the steel reaches the bath temperature. This does not correspond to the Metals Handbook definition of martempering and may logically be regarded simply as hot quenching. Thus, when most medium-carbon low-alloy steels (such as many of those shown in Fig. 2) are quenched into a liquid bath at 400° F., martensite formation goes to completion before the steel reaches the temperature of the bath, and the only advantage over conventional quenching is the somewhat retarded cooling rate through the temperature range of martensite formation.

(a measure of the efficiency of heat transfer within the metal) and the surface heat-transfer coefficient H. For practical purposes in quenching problems the thermal diffusivity may be taken as constant for carbon and low-alloy steels, so the cooling rate of such a piece of metal of given size and shape depends on the H-value of the quenchant, which is a measure of the rate at which heat is withdrawn from the surface. H is usually measured by the rate of change of depth of hardening with diameter of bar, and is influenced by *(a)* composition of coolant, *(b)* agitation of coolant, *(c)* temperature of coolant and *(d)* surface condition of the steel being quenched.

The cleanest practicable metal surface provides the least barrier to heat flow, and the smoother the metal surface the more uniform is the fluid flow. A vapor phase forms at the metal-quenchant interface and acts as an insulating blanket. This is minimized by suitable agitation (not too violent) such as rhythmic circulation of metal or quenchant to achieve uniform fluid flow, by submerged spray, and by using brine or caustic solution instead of water.

In true martempering, the temperature of the quenching bath depends on the martensite transformation range of the steel being treated. Figure 2 shows these ranges for 14 carbon and low-alloy steels. Two trends may be observed in these data. First, and most obvious, is the influence of carbon; with increasing carbon content the martensite range widens and is displaced to lower temperature. Second, the martensite range of a triple-alloy (nickel-chromium-molybdenum) steel is usually lower than that of single or double alloy steels of corresponding carbon content.

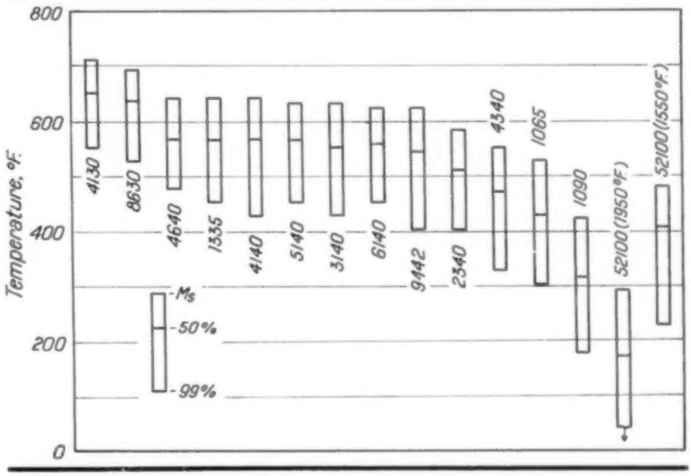


Fig. 2 — Temperature Range of Martensite Formation in Fourteen Carbon and Low-Alloy Steels (R. A. Grange and H. M. Stewart)

Normally in martempering the choice of coolant is confined to liquid metal or salt, because the required temperature — near M_s — is generally too high for oil.* Probably the only commercially feasible metal bath is a lead-bismuth alloy such as the eutectic melting at 255° F.; the vapor pressures of lead and bismuth are relatively low and their solubility in iron almost nil. Compared with a salt bath this metal bath has a far higher density, much higher conductivity, and a considerably lower specific heat. This means that with effective agitation the metal bath cools the work more rapidly, but the heat-absorbing capacity of the cooling system must be greater under continuous operation. Because the metal bath is more dense than steel, the work must be held down, whereas it can simply be suspended in a salt bath. The initial cost of the metal bath is greater but maintenance charges are likely to be less because of greater chemical stability. If the steel or the lead-bismuth becomes oxidized, particles of the oxidized alloy stick to the steel and are more difficult to remove than a film of salt, which dissolves in water. If the steel should be scaled, salt is better able to wet and penetrate the scale and so compensates in part for its lower conductivity. Under some conditions, salt may corrode the steel, but molten lead-bismuth does not. On the other hand, the mechanical problem of obtaining adequate agitation of a heavy metal bath is much greater than with a salt bath. The net result of all of these considerations is that martempering in salt baths is more common than in metal baths.

The first and most difficult problem in martempering is to quench rapidly enough to prevent

*Salt bath martempering of a part austenitized in cyanide is very hazardous because of the probability of an explosive reaction between the nitrite in the bath and the cyanide film on the part. Oil with a high boiling point has been used successfully up to about 400° F. (D. C. Miner, *Steel*, April 29, 1946, p. 88).

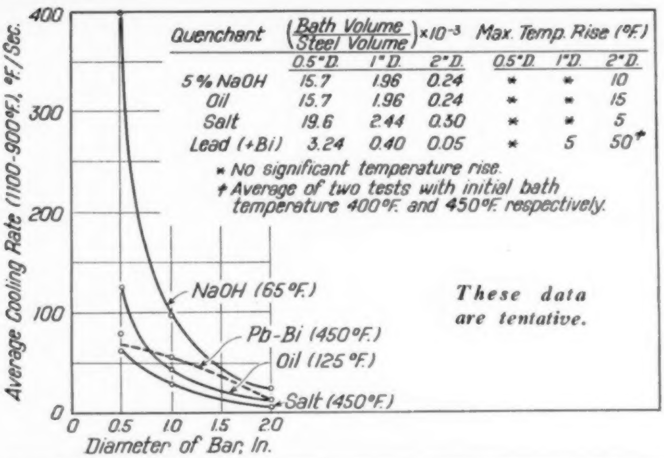


Fig. 3 — Influence of Section Size on the Cooling Rate of Steel in Four Quenching Mediums. The cooling rate plotted is the average rate between 1100 and 900° F. for the centers of round bars quenched in agitated liquids. These data are tentative.

the steel from transforming above M_S. R. L. Rickett, J. W. Stewart and W. G. Benz of our Laboratory recently investigated the relative cooling power of molten salt and lead-bismuth in comparison with oil and 5% NaOH solution. The effect of section size from 0.5 to 2 in. was determined for machined steel cylinders whose length was three times the diameter. For each size, a grade of steel was selected that would remain austenitic to a temperature lower than that of the molten bath. A small hole was drilled axially to the center of the cylinder and a thermocouple was spot welded to the cylinder at the base of the hole. The cooling curves were recorded on a special high-speed electrical recorder giving full-scale deflection in 0.75 sec. The temperature of the salt and lead-bismuth was 450° F.; that of the oil, 125° F., and of the caustic, 65° F. Both salt and metal baths were stirred mechanically, and the oil and aqueous baths were circulated by an external pump. The average velocity of the liquid flowing over the specimen was estimated to be 2 in. per sec. The cylinders were quenched one at a time, with the bath always at the test temperature before a specimen was quenched.

The test results to date, which are tentative, are summarized in Fig. 3, in which the average cooling rate between 1100 and 900° F. is plotted against the diameter of the bar. It is clear that under these conditions, which we believe represent favorable industrial usage, the cooling rate in salt between 1100 and 900 °F. is distinctly less than in oil. It is also to be noted that the cooling rate in lead-bismuth is consistently greater than in salt. The abnormal shape of the lead-bismuth curve may be associated with the relatively small volume of the bath in comparison with the other baths, as indicated in the ratio of bath volume to steel volume. It is evident that, at least under these specific conditions, the volume of the bath should be at least 500 times that of the steel in order to avoid a significant increase in temperature. However, when the molten bath can be artificially cooled, a much smaller volume or weight ratio is presumably adequate, with reported ratios ranging from 2 to 10 or more pounds of salt per pound of steel per hour.

The relative quenching power of several hot and cool baths may be demonstrated by hardness measurements taken at the surface and center of round bars of various diameters, as shown in Fig. 4, from Shepherd. It is evident from these data that salt at 400° F. is less effective than oil at 80° F. but more effective than oil at 400° F

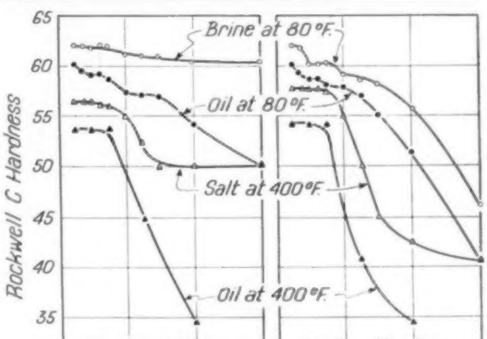


Fig. 4 — Effect of Quenchant and Mass on 8742 Steel Quenched From 1500° F. (B. F. Shepherd)

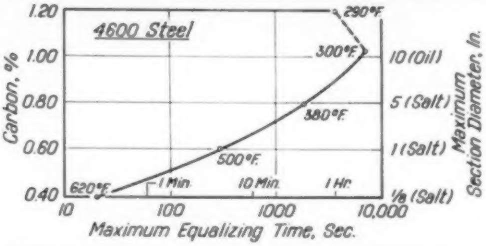


Fig. 5 — Maximum Equalizing Time Near M_s for 4600 Steels of Five Carbon Contents (E. S. Rowland and S. R. Lyle). Maximum sections (right-hand scale) are from B. F. Shepherd.

Equalization of Temperature at Ms

The center of the 2-in. cylinders mentioned on p. 68 required 10½ min. to cool from 1550 to within 5° F. of the salt bath temperature at 450° F. For industrial martempering salt baths, Shepherd found that the time required for the equalization of temperature of 1-in. rounds was 5 min. at 400° F., 4 min. at 500° F. and 3 min. at 600° F. when the steel was quenched from 1550° F. Insufficient time in the bath will leave thermal gradients with resulting stresses and may even permit subsequent transformation of the central austenite to upper bainite, pearlite, or ferrite. On the other hand, excessive time in the bath — aside from being expensive — may cause some lower bainite to form. However, this bainite is as tough as tempered martensite. Figure 5, from Rowland and Lyle (*Metal Progress*, V. 47, 1945, p. 907), shows how long austenite can be held near M_s without transformation, in nickel-molybdenum 4600 steels. The equalizing temperature near M_s is shown for each plotted point; the available time varies from 20 sec. for 4640 to well over 1 hr. for the outer layers of a carburized case. The scale on the right shows the diameter of the maximum treatable section, based on Shepherd's observation of the time required to cool various section sizes to the different bath temperatures. However, the limiting size factor above 0.40% carbon in this and most other low-alloy steels is not the equalizing time but the hardenability time, that is, the limiting cooling time that will bring the steel to M_s without the formation of nonmartensitic products. This will be discussed later, in the section concerning effect of mass.

Effect of Cooling Conditions Below Ms

When the temperature of the piece of steel has been equalized at or near the M_s temperature, the third step in martempering is to cool the piece to form martensite. Ideally, if maximum hardness is not required, the rate of cooling through the martensite range should be very slow to minimize thermal stresses, and to permit some relief of transformation stresses by self-tempering.

Because any salt film adhering to the steel dissolves readily in hot water, it is a temptation to quench the parts from the salt bath into boiling water, but this procedure has led to cracking in some higher-carbon steels. Air cooling to room temperature is customary for all grades of steel except for a few high-carbon, high-alloy types in thick section, which may require cooling in ashes or even in a furnace to avoid cracking.

Martempering in Relation to Distortion

Reduction of thermal stresses should reduce distortion and residual stress in martempered parts and this seems to be confirmed in practice, but the design of the part is always an equally important factor. Martempering also affords the unique opportunity of safely and easily straightening a part as it comes out of the equalizing bath while still substantially austenitic. Boyer's observations (*Iron Age*, July 3, 1947, p. 49) on the comparative distortion of martempered and oil quenched tubes of 52100 steel are summarized in Fig. 6. These tubes were austenitized alike, one

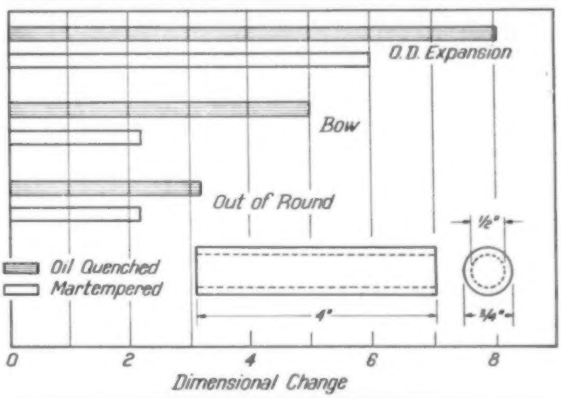


Fig. 6 — Comparison of Distortion in Oil Quenched and Martempered Cylinders of 52100 Steel (H. E. Boyer)

Table I — Control of Growth in Martempering (W. Olson and G. Nevins)
Composition: 1.0% C, 1.1% Mn, 0.5% Cr, 0.5% W, 0.2% V
Austenitizing Temperature: 1475° F.

Transformation Treatment	Percentage of Martensite Formed in Bath	Average Growth in ¾ x 3 x 4-In. Plate*	
		Solid, In. per In.	Bored (2-In. Hole), In. per In.
400° F. Salt	0	0.0010	0.0012
290° F. Oil	65	0.0005	0.0001
85° F. Oil	Nearly 100	0.0009†	0.0002

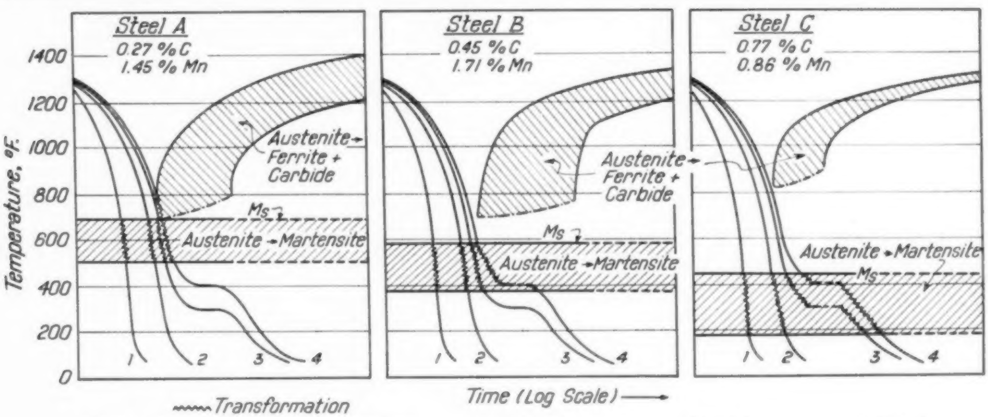
*Growth was measured after the plates were tempered to Rockwell C-60 at 400° F. †Warped.

set quenched in oil at 125° F. and the other set quenched in salt at 475° F., held 1 min. and then air cooled. Both sets were tempered at 300° F. before the distortion was measured. The martempered and tempered tubes show much less distortion than the oil quenched and tempered product.

In some applications, such as precision dies, it may be important to minimize dimensional changes during martempering. This is illustrated in Table I from the work of Olson and Nevins (*Steel*, Dec. 15, 1947, p. 88) on a chromium-tungsten-vanadium die steel. Conventional martempering near M_s produced too much growth, whereas quenching in cool oil caused excessive warping, but equalizing at 290° F. resulted in minimum growth, as measured after tempering. These results may be interpreted as showing the balance between thermal and transformation stresses, which oppose each other. In conventional martempering, equalizing before transformation minimizes thermal stresses, so transformation stress plays a major role uniformly throughout the specimen and expansion is unopposed. During quenching in cool oil the complex interplay of stresses produces warping, whereas quenching in oil at 290° F. causes the stresses to be more evenly balanced. Thus, dimensional changes can be controlled by adjustment of the temperature of the equalizing bath.

Cracking

The prevention of significant thermal stresses by retarded cooling during and after the formation of martensite, and the concurrent partial relief of transformational stresses by self-tempering



Cooling Curve	Quenching Medium	Steel A	Steel B	Steel C
1	Brine at 70°F.	No Cracks	Cracked	Cracked (?)
2	Oil at 70°F.	No Cracks	Cracked	Cracked
3	Salt at 300°F. (A.C.)	No Cracks	No Cracks	Cracked
4	Salt at 400°F. (A.C.)	No Cracks	No Cracks	No Cracks

Fig. 7 — Influence of Steel Composition and Quenching Process on the Quench Cracking of Cylinders ⅜ In. in Diameter, for Three Carbon-Manganese Steels

should reduce the probability of cracking, and this also is generally confirmed in practice. R. L. Rickett has recently determined the influence of carbon content and quenching process on the susceptibility to cracking of three steels in the form of cylinders ⅝ in. in diameter. The results are summarized in Fig. 7. On the cooling transformation diagrams of the three steels are superimposed the cooling curves corresponding to four types of quenching: brine at 70° F., oil at 70° F., salt at 300° F., and salt at 400° F. The composition of each steel was selected so as to insure transformation to martensite only, except that in the steel of lowest carbon content a little upper bainite formed during the quench in salt at 400° F., as indicated on the cooling curve. When the carbon content was low, even brine quenching caused no cracking. When the carbon content was increased to 0.45% with manganese at 1.7%, both brine quenched and oil quenched cylinders cracked, whereas with the eutectoid steel (0.77% carbon, 0.86% manganese) only the 400° F. martempering treatment prevented cracking.

Retained Austenite

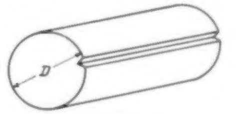
It has often been assumed that austenite transforms entirely to martensite during the air cooling step of martempering. But, as it is well known that some steels when oil quenched retain more austenite than when water quenched, still slower cooling might retain even greater amounts of austenite. Accordingly, R. A. Grange and K. G. Carroll of our staff investigated this point in two steels, with results which are summarized in Table II. The 4150 and 52100 steels were austenitized at 1550° F. in the form of notched cylinders as sketched, and quenched in duplicate in brine at 80° F., in oil at 170° F. and in salt at 450° F. The martempered cylinders were removed from the salt bath after 5 min., and cooled in air. Each specimen was then halved transversely with great care to avoid any tempering. The hardness and microstructure were determined on the polished and etched cross section. Using an X-ray spectrometer a search was made for retained austenite throughout the same cross section, but it was found only in the specimens quenched in oil. Under these conditions, no austenite was detected after the martempering of 4150 or 52100 steel.* It should be noted, however, that a considerable portion of the carbon content of the 52100 steel was undissolved and that had these specimens been austenitized at 1950° F. to dissolve all the carbon, room temperature would have been within the martensite formation range and some austenite would have been retained after all three treatments.

The X-ray observations showed tetragonal martensite in both oil quenched and brine quenched 52100, but not in any of the other specimens of either steel. The lack of it in the martempered specimens is to be expected from the self-temper-

*The trend of these results is opposite to that recently reported by M. Cohen and co-workers, and we are investigating this point further.

Table II — Comparison of Martempering, Oil Quenching and Water Quenching of 4150 and 52100 Steels

D = 1 in. for 4150
D = ⅞ in. for 52100



← 60° notch, 0.09 in. deep, 0.01-in. radius at base

Steel	Treatment*	Surface			Center		
		Hardness, Rockwell C	Structure	Retained Austenite‡	Hardness, Rockwell C	Structure	Retained Austenite‡
4150	Martempered	60	99+ M, Tr B	None	58	99+ M, <1 B	None
4150	Oil Quenched	61	100 M	<5%	59	100 M	<5%
4150	Brine Quenched	65	100 M	None	61	100 M	None
52100	Martempered	64	90 M, 10 B	None	55	80 M, 20 B	None
52100	Oil Quenched	66	99+ M, Tr B	<5%	65	99 M, 1 B	<5%
52100	Brine Quenched	66	100 M†	None	66	100 M	None

*Martempering in salt at 450° F. for 5 min., then cooled in air. Oil quenching in oil at 170° F. Brine quenching in brine at 80° F. Austenitizing at 1550° F. for 1 hr. All quenching baths agitated vigorously.
†Specimen cracked. M = Martensite. B = Upper Bainite.
‡The method used may not indicate the presence of austenite with certainty when less than 2% is present.

ing that occurred during air cooling. The distinctly lower hardness of each martempered product and the considerable content of upper bainite in the martempered 52100 steel should be noted; these may handicap the usefulness of martempered 52100 in some applications. If the austenitizing temperature were raised sufficiently to dissolve all the carbon in the 52100 steel, upper bainite might be eliminated but the gain would probably be offset by the undesirable coarser austenitic grain.

Mechanical Properties

No marked difference would be expected between the mechanical properties of products martempered and tempered and those quenched and tempered in the conventional manner, except possibly in fatigue if tempering has not equalized the residual stresses.* The similarity of properties is illustrated in Fig. 8 from the work of R. L. Rickett and F. C. Kristufek of our staff. This chart compares the notch-toughness of martempered and conventional quench-tempered 2340 steel at Rockwell C-40 and 4063 steel at Rockwell C-53 over the range of temperature from +300 to −300° F. A similar investigation of 6150 steel at Rockwell C-51 shows the same trend.

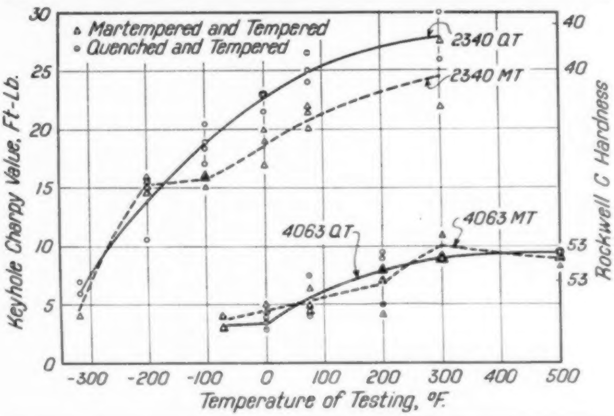


Fig. 8 — Comparison of Notch Toughness of 2340 and 4063 Steels Quenched and Tempered, and Martempered and Tempered

*Editor's Note: In *Metal Progress* for November 1948, A. C. Forsyth and R. P. Carreker reported a fatigue limit of 160,000 psi. for martempered 1095, compared with 124,000 psi. for water quenched 1095, with all specimens tempered to Rockwell C-53.

Effect of Mass

The final point to consider is the limitation of mass or section in martempering. With a given severity of quench or *H*-value, there is a limiting size of bar whose center will cool barely fast enough to transform entirely to martensite. This is illustrated in Fig. 9, which compares the limiting size of bar that can be hardened by martempering, by oil quenching and by water quenching 1045 and five alloy steels differing widely in hardenability.

These data are based on observations of hardness and microstructure in an end-quench test specimen of one heat of each of the six grades of steel. In each of the three steels (8630, 4150 and 4340) for which hardenability bands have been adopted, the hardenability curve lies within the band, but it should be recognized that other heats of any of the six grades are likely to show somewhat smaller or larger values than were observed for these particular heats. To determine the values shown on the left half of the chart the distance from the quenched end of the end-quench specimen, at which the martensite content dropped to 99.9%, was converted into diameter of bar whose center would have the same hardness (and presumably microstructure) when cooled as indicated on the chart. These values appear as vertical bars on the left half of the diagram. The *H*-values selected are considered typical of efficient quenching in water, oil and hot salt, and are assumed to be independent of the size of specimen. A check on the validity of some of the calculated bar sizes may be found by comparing the values for 52100 and 4150 on the left side of Fig. 9 with the data on center microstructure in Table II, on the preceding page.

For a considerable number of applications a fully martensitic structure is probably unnecessary, and A. L. Boegehold has stated (in *Transactions* S.A.E., V. 52, 1944, p. 472) that a center hardness 10 Rockwell-C units less than the maximum obtainable for a given carbon content may be considered as the acceptable hardness in the quenched condition for obtaining suitable properties after tempering. We have accordingly calculated also the limiting hardenable bar size on this basis. The corresponding distance from the quenched end of

the hardenability bar was then translated, as before. into the diameter of bar whose center would have the same hardness (and presumably microstructure) when cooled as indicated on the chart. These values appear as vertical blocks on the right half of Fig. 9.

It is obvious that the maximum diameter of bar by this criterion is much greater (actually from 25 to 300% greater) than the maximum diameter that can be made fully martensitic. It should be pointed out, however, that considerable amounts of nonmartensitic transformation products (pearlite, ferrite and bainite) were observed at the position on the end-quenched bar corresponding to this reduced hardness value. These amounts were as follows:

1045	15% Pearlite
8630	10% Ferrite and bainite
1340	20% Ferrite and bainite
52100	50% Pearlite and bainite
4150	20% Bainite
4340	5% Bainite

Thus a considerable proportion of the cross section of the larger bar will contain an appreciable amount of ferrite, pearlite or upper bainite. The influence of such a mixed structure on the mechanical properties of the steel is under study in several laboratories. Jominy has recently proposed a minimum of 90% martensite in regions under highest stresses (*S.A.E. Journal*, April 1948, p. 40). If this percentage is based on the average structure there will surely be local spots containing much less martensite and these are potential points of weakness and cracking. In any event, it is evident that martempering limits the production of a given quenched structure or hardness in a given steel to a smaller section size than oil or water quenching.

Summary

Ideally, martempering requires adjustment of composition, section size, cooling rate and bath temperature so that the treated part reaches the M_s temperature fully austenitic; then after equalization at the M_s temperature the part will be cooled so slowly that the temperature gradient is virtually nil. In practice this ideal is seldom attained because of the cost of adjusting these variables to each job, and because the product is acceptable if it does not crack and remains within the limit of permissible distortion and required final hardness.

The limitations of martempering are:

1. Composition: For a given section size, the minimum carbon or alloy content must be somewhat higher than in conventional quenching for the same percentage of martensite.

2. Section size: For a given composition, the section size that can be made fully martensitic (or treated to any lower hardness) is somewhat less than for efficient quenching in oil or water.

3. Less decarburization and scale are allowable in martempering.

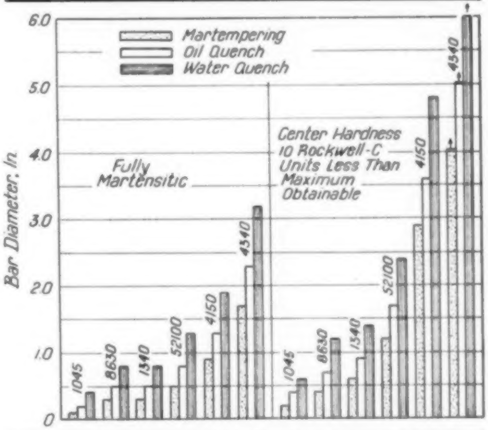


Fig. 9 — Approximate Maximum Size of Bars Hardenable by Water Quenching, Oil Quenching and Martempering. Data are based on end-quench test of one heat of each steel. H-values are assumed constant for each type of quenching as follows: Martempering, 0.25; oil quenching, 0.45; water quenching, 1.5.

4. More elaborate heat treating equipment is required.

5. Somewhat more time, space and equipment are needed to handle the same volume of work.

6. There are greater safety hazards in working with molten baths.

7. The salt film (or lead-bismuth particles) must be removed from the hardened product.

Offsetting these limitations, there are two outstanding advantages of martempering:

1. The steel is less likely to crack.

2. Distortion is minimized.

A probable additional advantage is improved control of inevitable dimensional changes, and a final advantage is that because of some self-tempering during air cooling the product may be suitable for some applications without further tempering.

PERSONALS

Upon graduating from Rensselaer Polytechnic Institute, **George Zuromsky** ⊕ has been employed as metallurgist at Chapman Valve Mfg. Co., Indian Orchard, Mass.

Joseph Cutro ⊕ is now employed by the Black-Clawson Co., Hamilton, Ohio, as assistant production manager.

Ching-Lin Tang ⊕, who graduated from Lehigh University in June 1948, is now doing graduate work at Purdue University, Lafayette, Ind.

Thomas S. Simms ⊕, formerly sales engineer for Metal Parts and Equipment Co., is a research consultant in metallurgy for the John Crerar Library of Chicago.

George M. Dinnick ⊕ has been placed in charge of the construction of a new plant for the Andrew Corp. of Chicago and the planning of a model village.

C. O. Anderson ⊕, formerly with Claud S. Gordon Co. of Ohio and the Lithium Co., is now operating as C. O. Anderson Co., Cleveland, for the sale of industrial heating equipment and controls, representing Maxon Premix Burner Co. and Charles A. Hones, Inc.

Roger W. Carothers ⊕, formerly sales engineer with the Dow Furnace Co., has recently joined the Hevi Duty Electric Co. of Milwaukee as Detroit representative.

Syl A. Meshorer ⊕ has been transferred by Amalgamated Steel Corp. from sales manager in the Detroit territory to general manager of the Cleveland office.

R. M. Linsmayer ⊕, who was previously metallurgist at the Knolls Atomic Power Laboratory of the General Electric Co., is now metallurgist in the research section of the Air Materiel Command at the Wright-Patterson Air Force Base.

Robert T. Rospond ⊕, a recent graduate of Lehigh University, is now metallurgical engineer with the New Jersey Zinc Co.

Warren W. Smith ⊕, formerly with Republic Aviation Corp. and Southern Metal Works, has accepted a position with Pan American Airways, Inc., as chemist in its Miami, Fla., laboratory.

William A. Franz ⊕, who graduated from Carnegie Institute of Technology in June 1948, is now employed by National Tube Co., Ellwood City, Pa., as a junior metallurgist.

Since graduation from Marquette University, College of Engineering, **Ralph Baumann** ⊕ has been employed by B. Hoffmann Mfg. Co., division of Grinnell Co., Inc., as a sales engineer in the Milwaukee region.

H. S. Spaulding ⊕, previously chief metallurgist at Reynolds Metals Co., plant No. 7, Louisville, Ky., is now chief metallurgist at Permanente Metals Corp.'s new rod, wire and cable plant at Newark, Ohio.

Walston Chubb, Jr., ⊕ is working for his master's degree in metallurgical engineering at Missouri School of Mines and Metallurgy and also doing research work for Ludlow-Saylor Wire Co.

John Stipp Hicks ⊕, who graduated from Colorado School of Mines in May 1948, is now employed as metallurgical engineer in the Aluminum Company of America's research laboratories in New Kensington, Pa.

Donald W. Williams ⊕, formerly research engineer at Battelle Memorial Institute, is now plant superintendent with Coast Metals, Inc., Canton, Ohio.

Clyde H. Krummel, Jr., ⊕, formerly with Bethlehem Steel Co. as an experimental engineer, is now with Miami-Dickerson Steel Co., Dayton, Ohio, as salesman.

PERSONALS

John T. Ransom, who has just finished the experimental work for his doctor's degree from Carnegie Institute of Technology, is now mechanical metallurgist in the engineering research laboratory of E. I. duPont de Nemours & Co., Inc., Wilmington, Del.

H. I. Phelps has been promoted from western regional manager of All-State Welding Alloys, White Plains, N. Y., to national sales manager.

John V. Hackett has been appointed superintendent of the Riverside Metal Co., Riverside, N. J.

Forrest P. Coonrod, a recent graduate of Purdue University, is now metallurgist at Federated Metals Division of American Smelting & Refining Co., Pittsburgh, Pa.

Formerly tool designer with Chase Brass & Copper Co., **S. F. Reiter** has started graduate studies in metallurgy at Yale University.

Harold W. Wyatt has been promoted by the Lunkenheimer Co., Cincinnati, from research engineer to head of the physical laboratory of the metallurgical division of the company.

L. B. Lumpkin, for 12 years connected with the New York office of the Bristol Co., has been transferred to Birmingham, Ala.

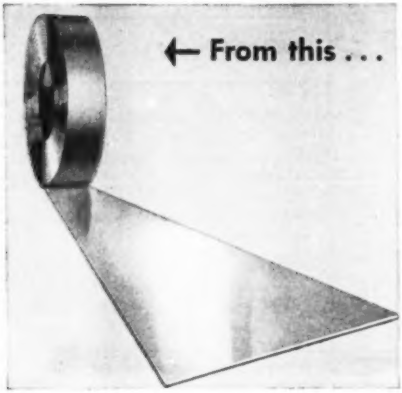
Sidney M. Lenhoff, formerly research metallurgist at the Detroit Diesel Engine Division, General Motors Corp., has accepted a position as metallurgical engineer with the Detroit Arsenal, Army Ordnance.

E. E. Parker, Jr., has recently joined Acme Radiator Division as general manager with headquarters in Thomasville, Ga.

Paul Ruzicka, formerly with Winchester Repeating Arms Co., New Haven, Conn., is now with Hamilton Watch Co. in the metallurgical research division.

Leaving the research department of Bethlehem Steel Corp., **J. H. Frye, Jr.**, has become director of the metallurgical division of Oak Ridge National Laboratory, Oak Ridge, Tenn.

John W. Whitehead, formerly chief engineer of the truck and trailer division of Reynolds Metals Co., is now a sales engineer for the McIlhany Equipment Co. of Roanoke, Va.



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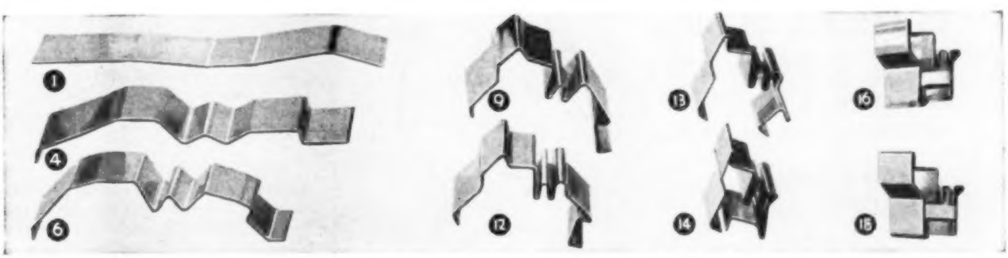

These cross sections, taken from nine of the 20 stands of a roll forming mill, illustrate progressive stages of fabrication from Kaiser Aluminum coiled sheet to finished section. In one continuous operation an important part of a window frame is rapidly formed!

PERSONALS

Maurice A. Embertson, who has been with Wheelco Instruments Co. for the past two years, has established Pyro-matic Industrials, Milwaukee, for sale and service of Wheelco instruments and associated equipment.

Robert I. Udell, formerly with Allison Bedford Foundry of the Allison Division of General Motors Corp. as sales engineer, is now operating the Indianapolis office of Metal Parts and Equipment Co., offering sales and engineering service for several companies.

Alvin A. Wisco, who has finished the Westinghouse graduate student training program, has taken a permanent assignment in the metallurgical section of the Westinghouse Lamp Division, Bloomfield, N. J.

Robert T. Howard, who was formerly with the Los Alamos Scientific Laboratory, is now metallurgist at Black, Sivalls & Bryson, Inc., Kansas City, Mo.

Richard W. Sweeney, formerly at Virginia Polytechnic Institute, is now employed as an engineer with the Buckeye Steel Castings Co., Columbus, Ohio.

Edward P. Patterson, who received his M.S. from Missouri School of Mines in June 1947, is now with the National Trade School at Kansas City, Mo., as senior mathematics instructor for the drafting division.

Clint Lundy, formerly with Reynolds Metals Co., is now with the Permanente Metals Corp. as a sales engineer in the Seattle district sales office.

Elmer A. Terwell, formerly with the Salkover Metal Processing Co., is now midwestern representative for Ashworth Bros., Inc., Worcester, Mass.

R. F. Cornelissen, who was previously materials engineer for the Navy Department at the Bethlehem Shipyard, is now chief of the materials research laboratory at Electronics Station, Air Materiel Command, Cambridge, Mass.

Sam Tour & Co. announces that **Alexander Gobus**, who is a materials engineer with the company, has been appointed to direct the X-ray laboratories of the company, which will work under the U. S. Air Forces and the Navy Bureau of Aeronautics.

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PERSONALS

Hugh J. McDonald ⊕ was recently appointed professor of physical chemistry and chairman of the department of chemistry at Loyola University School of Medicine in Chicago. Until recently he was professor of chemistry and director of the corrosion research laboratory at Illinois Institute of Technology.

After 12 years as assistant director of metallurgical research at the Lunkenheimer Co., **Austen J. Smith** ⊕, past chairman of the Cincinnati Chapter of the American Society for Metals, has been appointed associate professor of metallurgical engineering at Michigan State College, East Lansing, Mich.

R. C. LeTourneau, Inc., Peoria, Ill., announces the appointment of **Hans A. Bohuslav** ⊕ as special engineering consultant. Mr. Bohuslav was formerly with Engineering Controls, Inc., Los Angeles.

The Kaiser Co. announces the promotion of **George B. McMeans** ⊕ from assistant general superintendent of the Kaiser steel plant at Fontana, Calif., to general superintendent.

Carl L. Radway ⊕, who has been with the Cuyahoga works of the American Steel and Wire Co. since 1916 (most recently as department superintendent of production planning), has been appointed division superintendent of the cold rolling mills at the same works in Cleveland.

R. W. Milow ⊕ has recently been designated manager of the alloy steel department of the J. T. Ryerson & Son's Philadelphia office.

Lt. Comdr. R. Doughton ⊕ has returned to active duty in the Navy as assistant material officer for engineering at the Norfolk Group, Atlantic Reserve Fleet.

After resigning from the teaching staff of the metallurgical engineering department of Purdue University, **H. George Johannessen** ⊕ joined Ligon Bros., Detroit, in an engineering capacity.

Arthur E. Hageboeck ⊕, executive vice-president of Frank Foundries, Inc., Moline, Ill., received the first gold medal award of the Gray Iron Founders' Society for his outstanding contributions to the general welfare of the industry and his brilliant accomplishment in establishing foundry cost groups throughout the country.

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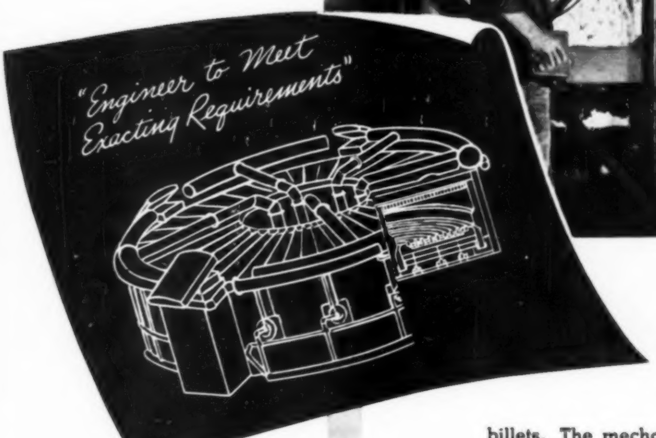

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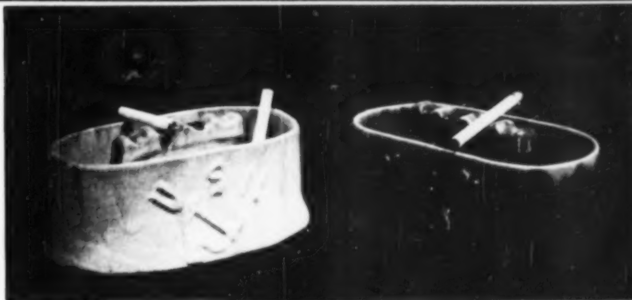
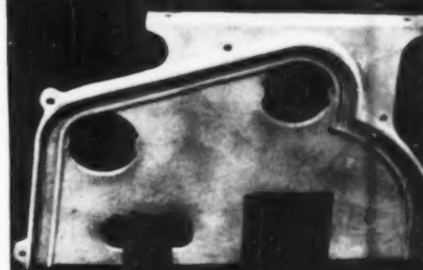


LONG a disciple of Le Corbusier, we derive much pleasure from Stamo Papadaki's Le Corbusier (published by Macmillan Co.), the latest of several books on a remarkable craftsman, architect, painter and writer, who has perhaps contributed most to the concepts of houses and buildings as tools for living.



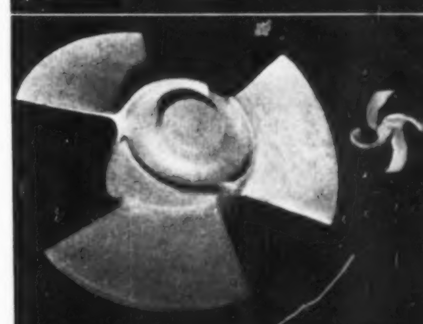
It has been said of him, and with little exaggeration, that he gave architects a new vocabulary. He freed buildings from weight, the greatest single innovation of modern architecture — and gave us volume as the essential material of our designs. Le Corbusier preached the doctrine that "that which is truly functional is truly beautiful", a yardstick which, if applied with intellectual integrity to contemporary furniture, dwellings, machines, will reveal startling discrepancies.

Thinking of our friend, Branchusi, whose masses simulate motion, we believe both he and Le Corbusier, being Frenchmen, would joyfully embrace Commander R. T. Simpson of the U.S. Navy, who crystallized a bit of logic in the truly functional ash trays shown above. This ash tray is so designed that any burning cigarette, resting on the edge of the oval bowl and the center post, cannot possibly fall anywhere but in the bowl, i.e., the minimum distance of support being more than half the length of the cigarette. (Study this one, — it's a rare bit of design.)

Being essentially engineers thinking in terms of functional efficiency and ultimate life of our product, we have extended this thinking far into foundry processes. A General Alloys heat or corrosion resistant casting more often than not is a product conceived on the drafting board and executed in the foundry to utilize the maximum properties, metallurgical and physical (of the alloy best suited), *thru special foundry techniques* tailored to the job.

Amazing though it would appear to most M.P. readers, we continually receive orders specifying steel mill analysis for castings. We even received one for an "Armco" casting. Almost every day's mail brings in orders or inquiries for some of the hundred-and-one variations of 18-8 listed in steel mill sales literature.

While it is possible to cast most of the alloys (and cast many that are not available in mill forms), such mill specifications often produce castings with radically different performance than the mill product. It is, or should be, generally known that extremely low carbons, for example, create very low fluidity, necessitating their being poured at much higher temperatures when cast in thin sections. The hotter metal erodes more sand and ladle lining into the metal. Heat treating a piece of "yard goods" of uniform section is a different problem than that of irregular sections. The heating and cooling rates of different portions of the same casting and the consequent stresses vary with the section.



A current inquiry is for castings 18" in diameter, 2 ft. long, with a Mae West contour and a ⅛" wall section. These are specified in a steel mill analysis developed to save strategic materials and having several fractional alloying elements.

Such material in cast form in a trilaminar structure differs greatly from the unilaminar in principle of physical characteristics. In heat and corrosion-resistant alloys, not subject to grain refinements by commercial heat treatments, it is necessary that the characteristics of casting be understood so that their many points of *superiority* to sheet can be fully utilized.

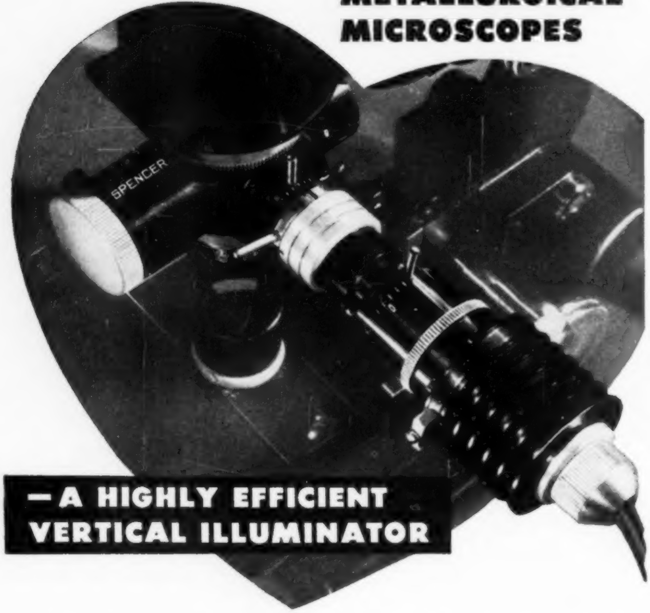
If, dear reader, you now find yourself an "expert" in designing gas turbines and similar high temperature mechanism or Ordnance components, we humbly implore you to ask the boss for a few days to start your high temperature alloy education. If you will pay us a visit we will do our best to acquaint you with the major fallacies in design and metallurgy which have combined to produce the definitely "half-baked" jet and turbine alloy components we taxpayers are buying. These are largely designed by recent "experts" with little or no background in high temperature mechanism.

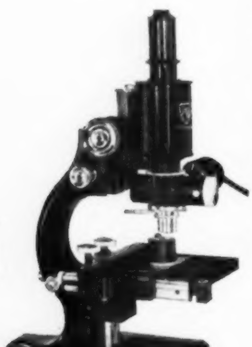
H. H. Harris

An advertisement of General Alloys Company, Boston

"Oldest and largest exclusive Mfrs. of Heat and Corrosion-Resistant Alloys"

THE FOOTSTEPS OF GENERAL ALLOYS MARK THE PATH OF AN INDUSTRY





LOW-TEMPERATURE PROPERTIES

IN the *Journal of Technical Physics* (U.S.S.R.), Vol. 16, No. 5, 1946, p. 515 to 554, there appeared a series of four articles entitled "Mechanical Properties of Metals and Alloys in Tension at Low Temperatures", by V. I. Kostenetz. These articles discussed the properties of several commercially pure metals, nonferrous structural alloys, carbon steels, alloy steels, and solders, all at +63, −321 and −424° F.

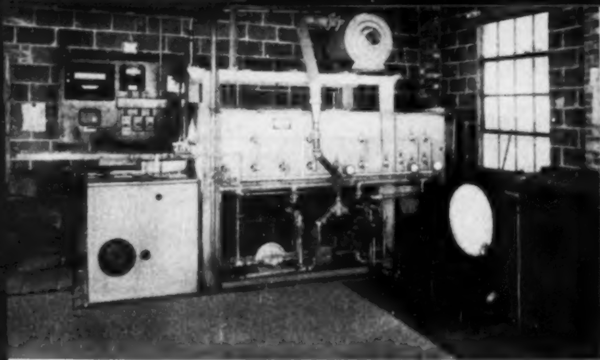
The tests were made in a vacuum bottle containing about three pints of liquefied nitrogen or hydrogen surrounding the specimen at the start of each test. Loads up to 3000 lb. were applied by means of a piston and a cylinder containing oil. The specimens had a gage length of 30 mm. and a diameter of 3 mm. The elongation of the specimens was measured with a cathetometer, through a longitudinal window in the metal vacuum bottle. Each test required about 15 min.

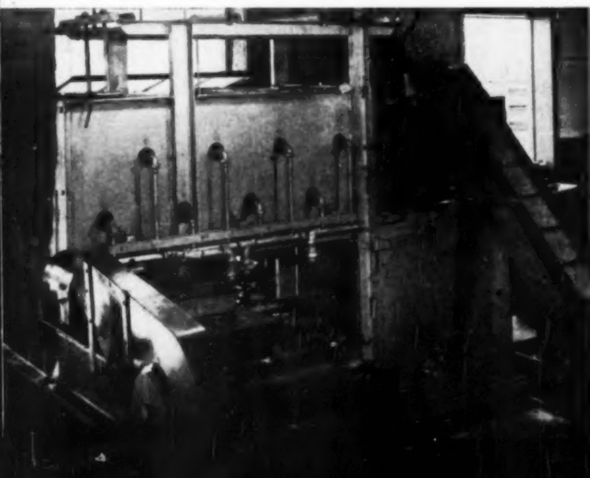
The test results for 33 of the metals are summarized in the table on p. 84. Data for the solders were reported in last month's *Metal Progress,* p. 884.

Commercially Pure Metals — The tensile strength has the same value at −424 as at −321° F. for molybdenum and tin, when brittle fracture occurs at these temperatures. This agrees with the hypothesis of Joffé that the brittle strength is independent of temperature. The face-centered cubic metals increase in both strength and ductility as the temperature of testing is lowered. For the metals that are not face-centered cubic, the behavior is inconsistent.

Nonferrous Alloys — In order to determine whether *alloys* having a face-centered cubic crystal structure retain ductility at low temperature in the same way as face-centered cubic *metals,* eleven nonferrous alloys were tested. Although the tensile strength of each alloy increased as the test temperature was decreased, the percentage increase was less than for the pure metals. Generally the elongation increased and the reduction of area remained about the

(Text continued on p. 86)
(Table is on p. 84)





(Abstract begins on p. 82)

Low-Temperature Tensile Test Data

Metal	Composition	Tensile Strength, Psi. +63° F.	Tensile Strength, Psi. −321° F.	Tensile Strength, Psi. −424° F.	Elongation, % +63° F.	Elongation, % −321° F.	Elongation, % −424° F.	Reduction of Area, % +63° F.	Reduction of Area, % −321° F.	Reduction of Area, % −424° F.
		Commercially Pure Metals								
Aluminum	99.7%, rod	17,000	30,000	50,000	29	42	45	86	75	66
Silver	99.41%, rod	26,000	41,000	51,000	39	82	83	90	83	79
Copper	99.9%, rod	34,000	54,000	65,000	29	41	48	70	72	74
Nickel	99.8%, sheet	64,000	90,000	112,000	35	46	48	77	69	69
Lead	99.98%, cast	4,000	6,400	10,100	26	34	36	—	—	—
Molybdenum	99.31%, rod	70,000	77,000	77,000	3	0	0	3	3	4
Tin	99.74%, cast	5,100	10,100	10,400	29	4	0.6	91	4	0
Magnesium	99.9%, cast	17,000	23,000	30,000	5	5	5	10	7	8
		Nonferrous Alloys								
Leaded Brass	65 Cu, 34 Zn, 0.9 Pb	60,000	84,000	91,000	38	42	41	53	50	48
Leaded Muntz Metal	59 Cu, 40 Zn, 1.1 Pb	64,000	84,000	97,000	32	37	34	35	38	35
Tin Bronze (cast)	88 Cu, 10 Sn, 1.9 Pb	44,000	54,000	60,000	30	12	9	28	12	14
Beryllium Copper	98.5 Cu, 1.5 Be	92,000	115,000	131,000	20	34	40	68	64	62
Phosphor Bronze	93 Cu, 6.5 Sn, 0.4 Pb	90,000	119,000	135,000	12	29	29	61	54	51
Aluminum Bronze	95 Cu, 5 Al	60,000	83,000	92,000	61	84	83	74	76	72
Manganin (sheet)	85 Cu, 12 Mn, 3 Ni	68,000	91,000	99,000	18	70	27	23	39	33
Duralumin (17S)	4.2 Cu, 0.6 Mg, 0.6 Mn	58,000	74,000	97,000	15	16	16	25	20	16
Lautal (25S)	4.3 Cu, 0.8 Mn, 0.9 Si	31,000	45,000	60,000	7	9	12	14	11	13
Silumin (cast)	90 Al, 10 Si	18,000	18,000	33,000	1.2	0.8	1.4	0.6	0	1.5
Elektron (cast)	96 Mg, 3.5 Al, 0.2 Mn	13,500	20,000	24,000	0.5	0.4	0.4	1	1	1
		Carbon Steels (Annealed at 1470° F.)								
1010	Yield Ratio, −321° F.	51,000	117,000	141,000	38	8	0	77	6	4
1020	0.92	61,000	132,000	165,000	30	21	0	76	33	5
1025	0.95	74,000	132,000	179,000	32	21	0	66	3	2
1035	0.975	92,000	154,000	178,000*	20	10	0*	54	6	5
1040	0.925	84,000	151,000	200,000	21	18	0	68	45	3
1050	0.86	102,000	165,000*	206,000	20	12*	0	51	*	3
		Alloy Steels (Annealed at 1470° F., except as indicated by footnotes)								
25N3	3.02 Ni, 0.25 Cr	94,000	142,000	173,000	24	23	0	59	29	2
12ChN2	1.62 Ni, 0.77 Cr	73,000	122,000	169,000	25	20	0	75	52	2
3312	3.26 Ni, 0.98 Cr	91,000	149,000	169,000	21	19	3	54	30	4
EN5	5.01 Ni, 0.22 Cr	141,000	206,000*	209,000*	17	8*	1*	44	*	*
EChTM†	0.08 Mo, 1.16 Cr	80,000	142,000	189,000	28	18	0	64	23	0
ESCh8	2.8 Si, 0.4 Ni, 9.5 Cr	119,000	145,000	148,000*	19	0	0*	50	9	*
5ChNM	1.7 Ni, 0.8 Cr, 0.3 Mo	114,000	171,000	202,000	17	15	1	55	30	4
EYa2‡	9.3 Ni, 18.9 Cr	109,000	242,000	188,000*	60	42	20*	67	51	*

*Fractures occurred at the fillet. †Annealed at 1250° F. ‡Annealed at 2100° F. (Abstract continued on p. 86)

AMERICAN
Brake Shoe
COMPANY

ELECTRO-ALLOYS DIVISION

ELYRIA, OHIO

LOW-TEMPERATURE PROPERTIES

(Abstract starts on p. 82)
same or decreased as the temperature was lowered. The face-centered cubic alloys remained ductile down to −424° F., but the cast aluminum-silicon and magnesium-aluminum alloys were brittle at all test temperatures.

Stress-strain curves were plotted for the alloys, and the yield strength was found to be far from the point of rupture. On the basis of tensile strength, ductility and yield strength, phosphor bronze and beryllium copper were chosen as the most suitable alloys for use at low temperature. Manganin is better than brass because of its higher yield strength.

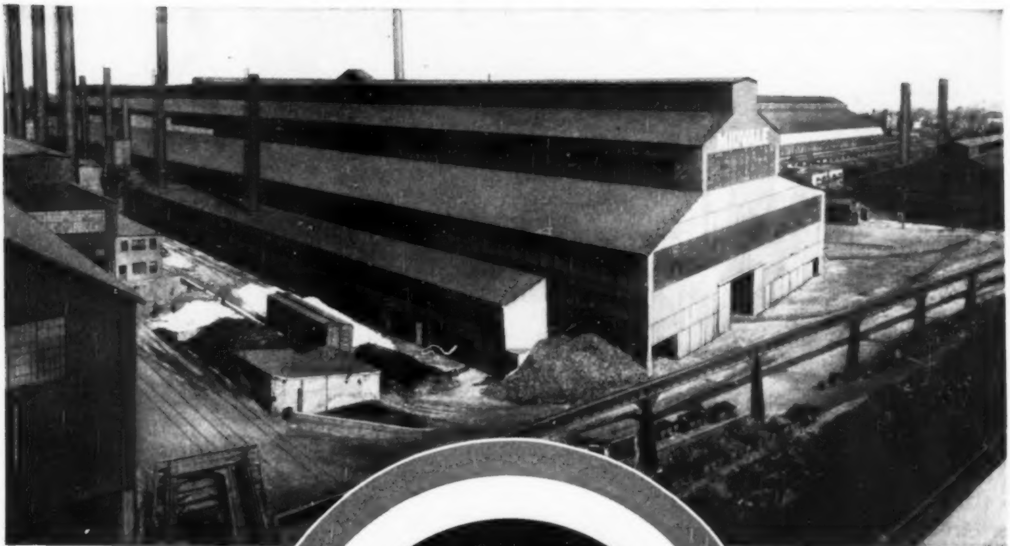
Carbon and Alloy Steels — This investigation was carried out with a view to replacing nonferrous alloys and high-alloy steels with low-alloy steels in some parts designed for use at low temperature. Eight carbon steels and eight alloy steels were tested in the annealed condition.

The standard carbon steels contained about 0.65% Mn, 0.25% Si, 0.035% P, and 0.025% S. The tensile strength increased with decreasing temperature, and both elongation and reduction of area decreased with decreasing temperature. The yield strength of these steels approached the tensile strength at −321° F., indicating that this is near the brittle temperature. Elongation was zero at −424° F.

The alloy steels were standard round or square rods and had the compositions given in the table on p. 84, with about the same manganese, silicon, sulphur, and phosphorus contents as the carbon steels. The tensile strength of these steels increased as the temperature decreased. The ductility generally decreased slightly at −321° F. and dropped to a low value at −424° F.

On the basis of these results, the low-alloy steel 25N3, and perhaps also 3312 and EN5, seemed suitable for use at low temperature.

Solders — Lead-base, tin-base and silver-base solders also were tested at +63, −321 and −424° F. The data have been reported on p. 884 of the December 1948 issue of *Metal Progress*, where the results of other low-temperature tests on solders were printed also.


MIDVALE

HYDROGEN FROM CORROSION*

SEVERE DAMAGE often occurs in petroleum processing equipment long before significant corrosion is apparent. Embrittlement and blistering have been encountered in equipment handling sour crudes, sour natural gases and gasolines, hydrocarbons, and hydrofluoric acid. The seriousness of the problem is emphasized by the fact that more than 50 blistered vessels have been found in plants of the Phillips Petroleum Co. alone.

Numerous photographs were shown of small blisters 1/8 in. or less in diameter, and some more than 12 in. in diameter. Actual equipment in which blistering was found and actual failures are described. Cracks form at the ends of the blisters, at right angles to the blisters and the plane of the plates.

A blister was tapped and the enclosed gas was analyzed and found to contain 99.5% hydrogen by volume. Measurements of the pressure developed in the blisters showed values ranging from 135 to 2700 psi. Chemical analysis of blister-free and blistered steel plates showed no essential differences in composition. Tensile tests revealed no marked differences. Impact tests and slow-bend fractures indicated banded and laminated structures.

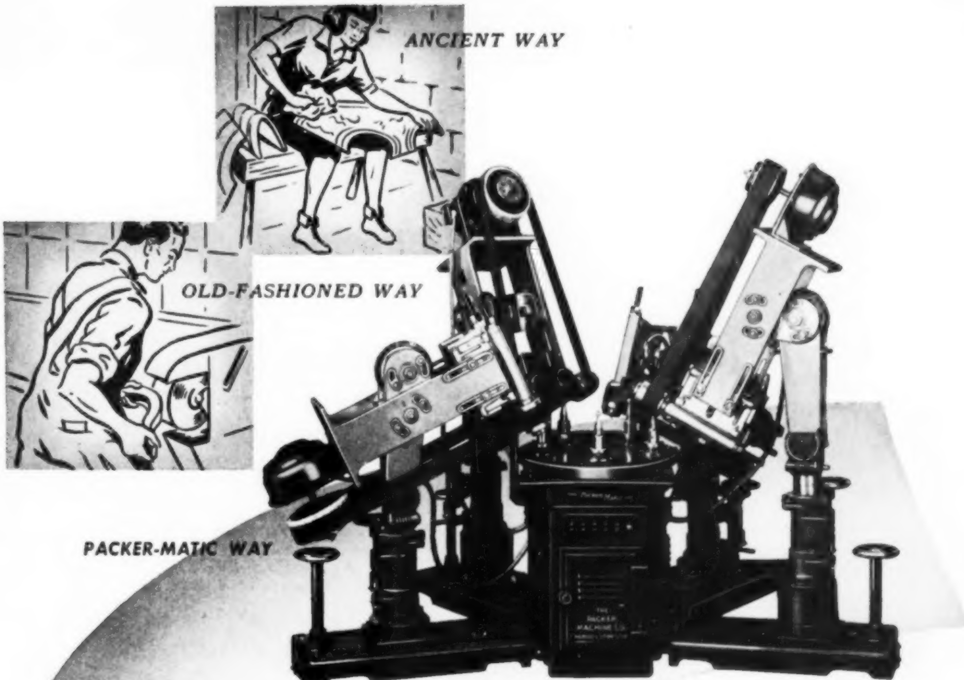
Etching with Stead's reagent showed bands of segregated phosphorus for blistered steels and no banding for blister-free steels. Cracks and blisters appeared to be associated with the phosphorus-rich bands. Reference was made to a previous investigation that indicated increased solubility of hydrogen with increased phosphorus.

Evidence was presented to show that large and small inclusions in the steel serve as nucleating points for the blisters. A photograph was shown of a blister that developed along a large slag inclusion. Unwelded gas pockets and laminations also nucleated blisters.

Hydrogen sulphide in the process liquor promotes blister formation and embrittlement. Sucker rods, 12% Cr valve springs, hardened valve plugs, bolts and other

(Continued on p. 90)

*Abstracted from "Effects of Hydrogen Generated by Corrosion of Steel", by M. H. Bartz and C. E. Rawlins. Paper presented before the National Association of Corrosion Engineers, April 1948.


ANCIENT WAY
OLD-FASHIONED WAY
PACKER-MATIC WAY

Who said it costs more

Here's where Stainless actually cuts cost 42.7%

COMPARISON AND

Cold Rolled Steel as against Stainless Steel

COLD ROLLED STEEL

Basic Cost of Tools Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0152
Punch Press Operations	$.0180
Preparation for Chrome Polish cold rolled before plating to remove "peel" and prepare finish to take clear color.	$.0224
Cost of Chrome Plating including depreciation of equipment.	$.1331
Plating Scrap Material scrapped because of prohibitive cost of stripping and re-chroming.	$.0140
Inspection	$.0060
Assembly line hold-ups Costs over Time Study standard hour due to "built-up" pieces and chrome flashes interfering with assembly.	$.0230
Finished units rejected or returned due to chipped or peeled plating resulting in "seconds" on line.	$.0480
Cost of material .025" Stock less scrap value.	$.0121
Total	$.2918

to use Stainless Steel?

ANALYSIS OF COSTS

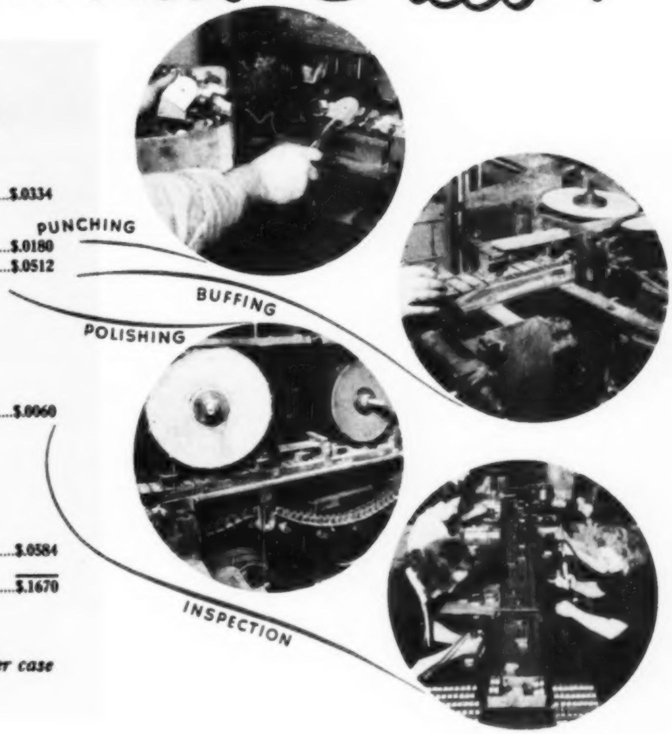
as experienced by Dart Mfg. Co., Mason, Mich.

STAINLESS STEEL

Basic Cost of Tools — Experienced life of tools plus average cost of maintaining dies, pro-rated basis.	$.0334
Punch Press Operations	$.0180
Polish and Buff — including depreciation of equipment and re-running of faulty buffing.	$.0512
Inspection	$.0060
Cost of Material .020" Stock less scrap value.	$.0584
Total	$.1670

Cold Rolled Total Costs . . . . $.2918
Stainless Total Costs 1670
Actual Experienced Savings . . . . $.1248 per case

Percentage Reduction in Cost 42.7%



THE "Metro-Meter" is a little device you'll soon be seeing a lot more of. It's a dial-reading steel rule with built-in scribe that men just naturally "take to" because it's practical, obviously useful, and, encased in Stainless Steel, is permanently good looking.

It's the case we want to talk to you about. Originally it was made of cold rolled carbon steel, chrome plated. The steel, itself, was inexpensive. But by the time it was prepared for plating, and plated—after the costs for rejections and returns due to over-plating, under-plating, chipping and peeling were added—each case cost a little over 29 cents.

By using lustrous satin-finish Stainless Steel in place of cold rolled carbon steel, however, all plating costs as well as rejections and returns were eliminated. Even though the initial cost of the Stainless Steel used was about five times that of the carbon steel formerly used, the final *finished* cost in Stainless was exactly 16.7 cents per case—a saving of almost 12½ cents each, which means a 42.7% reduction in cost.

What is more, with the magic word "Stainless" now stamped on the case, an almost irresistible plus has been added. Sales for the "Metro-Meter" which formerly had been good, immediately became considerably better. Thus, Stainless has done here what it has done for many other products – improved appearance, increased durability and reduced sales resistance. And in this instance, it has actually reduced costs as well. In short, a product made of Stainless Steel does *not* necessarily cost more—it only looks as though it did.

We would be glad to have the opportunity to show you where U·S·S Stainless Steel can be applied to improve YOUR product – to increase its desirability – and, more often than you may expect, to reduce its cost as well.

AMERICAN STEEL & WIRE COMPANY, GENERAL OFFICES: CLEVELAND, OHIO
CARNEGIE-ILLINOIS STEEL CORPORATION, PITTSBURGH & CHICAGO
COLUMBIA STEEL COMPANY, SAN FRANCISCO · NATIONAL TUBE COMPANY, PITTSBURGH
TENNESSEE COAL, IRON & RAILROAD COMPANY, BIRMINGHAM
UNITED STATES STEEL SUPPLY COMPANY, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

United States Steel Corporation Subsidiaries
Room 2061 Carnegie Building, Pittsburgh 30, Pa.
☐ Please send me the new book, "An Introduction to U·S·S Stainless Steel."
☐ Please have a Stainless representative call on me.

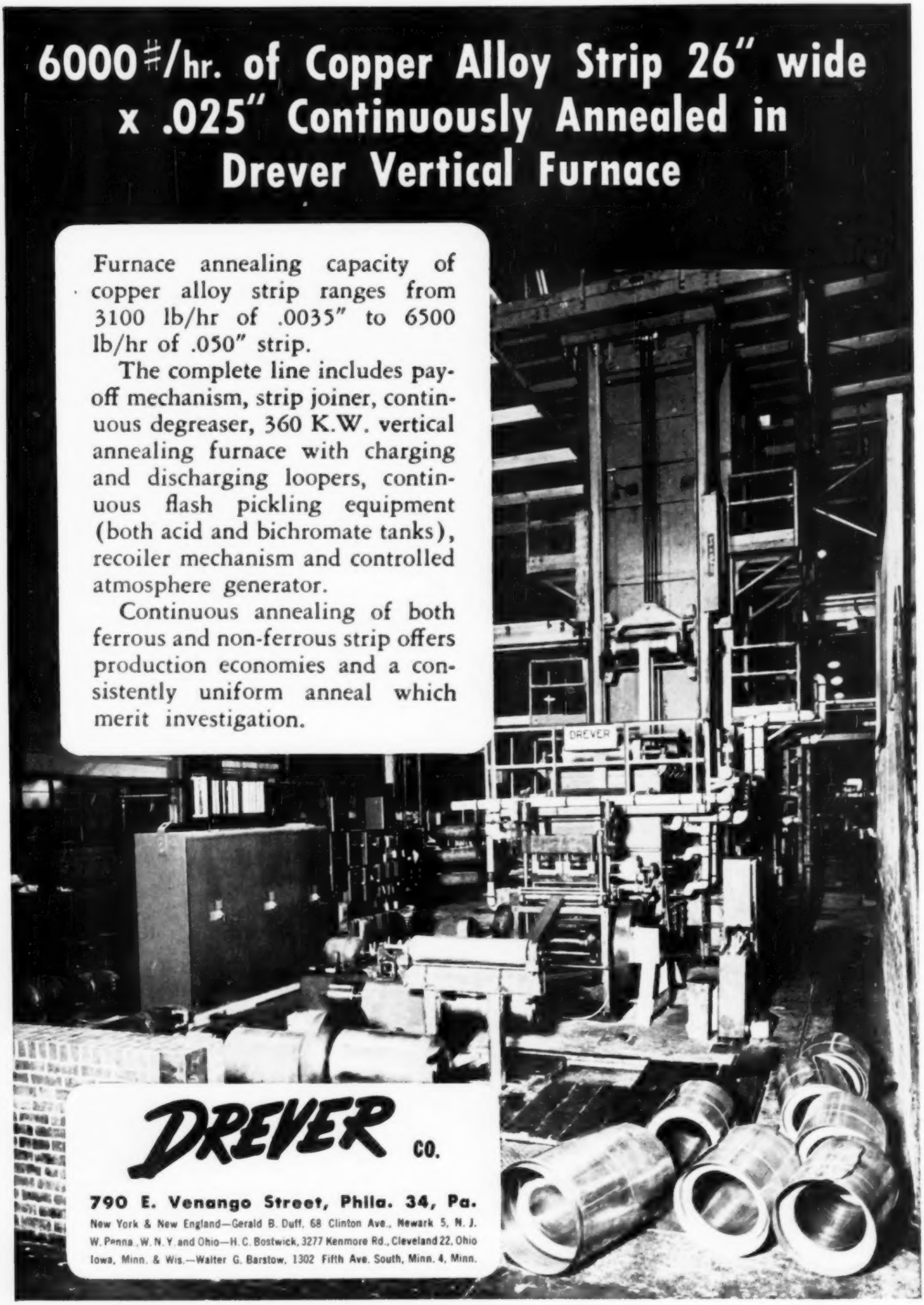
Name..
Position..
Company..
Address..
City...................... Zone.... State............

USS

U·S·S STAINLESS STEEL

SHEETS · STRIP · PLATES · BARS · BILLETS
PIPE · TUBES · WIRE · SPECIAL SECTIONS

UNITED STATES STEEL


6000#/hr. of Copper Alloy Strip 26" wide x .025" Continuously Annealed in Drever Vertical Furnace
Furnace annealing capacity of copper alloy strip ranges from 3100 lb/hr of .0035" to 6500 lb/hr of .050" strip.
The complete line includes pay-off mechanism, strip joiner, continuous degreaser, 360 K.W. vertical annealing furnace with charging and discharging loopers, continuous flash pickling equipment (both acid and bichromate tanks), recoiler mechanism and controlled atmosphere generator.
Continuous annealing of both ferrous and non-ferrous strip offers production economies and a consistently uniform anneal which merit investigation.
DREVER
DREVER CO.
790 E. Venango Street, Phila. 34, Pa.
New York & New England—Gerald B. Duff, 68 Clinton Ave., Newark 5, N. J.
W. Penna., W. N. Y. and Ohio—H. C. Bostwick, 3277 Kenmore Rd., Cleveland 22, Ohio
Iowa, Minn. & Wis.—Walter G. Barstow, 1302 Fifth Ave. South, Minn. 4, Minn.

WHAT'S NEW
IN MANUFACTURERS' LITERATURE
Use the prepaid postcard on this page to obtain the helpful literature described on these two pages.

1. Alloy Steel
"Rycut" new free machining alloy steel with hardness comparable with that of AISI 4150—SAE 4150. Now available in round, square and flat bar stock, in hot rolled and annealed condition or heat treated ready to use. Bulletins furnished on request. *Jos. T. Ryerson & Son, Inc.*

2. Alloys, Aluminum
More than 150 pages of up-to-date information, tables, and data on all the Alcoa aluminum alloys, including temper designations. *Aluminum Co. of America.*

3. Alloys, Heat Resistant
Interesting information not widely available in America is included in the brochure "Magnesium-Cerium-Zirconium Alloys" which will be sent free on request. *Cerium Metals Corp.*

4. Bars, Steel
New booklet gives illustrated descriptions of Union-drawn steels used for carburizing and requirements which each serves. Also includes tables of shapes and sizes available. *Republic Steel Corp.*

5. Brazing
6-page, colorful leaflet discusses advanced brazing facilities and applications. *Ferrotherm Co.*

6. Brazing
Bulletin 17 just released with instructions for brazing fittings to pipe and tubing with Easy-Flo and Sil Fos fluxes. *Handy & Harman.*

7. Castings, Bronze
New 4-page bulletin contains information on applications, physical characteristics and structure of non-granular bronze. Also table of stock bar sizes and illustrations of both sand and centrifugal castings. *American Non-Gran Bronze Co.*

8. Casting, Centrifugal
First detailed information on the Centri-Die process of centrifugal casting in permanent molds contained in a new bulletin furnished on request. *Lebanon Steel Foundry.*

9. Castings, Corrosion-Resistant
Valuable technical data on corrosion-resistant castings and specialties are presented in new bulletin. *Stainless Foundry & Engineering Co.*

10. Castings, Meehanite
Bulletin No. 29 presents in great detail an accumulation of machining data on various types of Meehanite castings, according to the type of machine tool. Particularly useful as a set-up guide. *Meehanite Metal Corp.*

11. Controls, Hydraulic
Folder K L-43 gives well illustrated description of water-hydraulic high pressure control valves, prefilling valves, stop valves, check valves, by-pass, shut-off, etc. *Hydropress, Inc.*

12. Corrosion, Control
Two new booklets just issued; one entitled "Salt as a Corrosion Problem" describes how corrosion by salt can be overcome. The second is a catalog listing of 200 standard products for corrosive and high temperature service, checked by the manufacturers of each item. *International Nickel Co.*

13. Cutting Oils
For the right combination to suit your specific requirements, write for the Booklet "Cutting Fluids for Better Machining". *D. A. Stuart Oil Co.*

14. Electrodes, Welding
New catalog presents complete line of shielded-arc electrodes for welding of mild steels and alloy steels; gives complete specifications, operating characteristics, mechanical properties, applications. *McKay Co.*

15. Electroplating
Metal Fluoborate Solutions described in technical bulletin ZF-1 outlines new approach to zinc plating. Bulletin LTF-1 describes lead-tin alloy plating from Fluoborate Bath and Manual CF-1, copper fluoborate. *General Chemical Div.*

16. Forgings
16-page illustrated leaflet discusses forgings with interesting details on applications and facilities. *Champion Forge Co.*

17. Forgings
28-page picture-packed booklet shows how men and machinery hammer and press out 80 million pounds of forgings a year. Step-by-step picture of operations includes die shop, forge, finishing and inspection, testing and analysis. *Drop Forge Div., Willys-Overland Motors, Inc.*

18. Furnaces
New 32-page fully illustrated catalog on Vapocarb-Hump furnaces. Describes the triple-control method of regulating atmosphere, and features improved control by use of fluid pump assembly. *Leeds & Northrup Co.*

19. Furnaces
Two-page color brochure now available briefly describing line of furnaces and complete plants from openhearth furnaces to finished primary steel and through heat treating lines to final production item. *Loftus Engineering Corp.*

20. Furnaces, Brazing
Fully descriptive folder on furnace brazing, with many suggested "do's" and "don'ts". *Electric Furnace Co.*

21. Furnaces, Controlled Atmosphere
Detailed literature describes economical and trouble-free heat treating with reciprocating, controlled atmosphere furnaces. *American Gas Furnace Co.*

22. Gas Analyzer
An automatic recording gas analyzer, infrared absorption type, particularly useful in petroleum, chemical and allied industries. Fully described in bulletin XXXI. *Baird Associates, Inc.*

23. Gas Analyzers
New bulletin 213 illustrates Burrell "Industro" simplified portable gas analyzer for on-the-job use by control engineers and laboratory technicians. *Burrell Technical Supply Co.*

24. Generator, Gas
An extremely informative booklet gives new information on inert gas production, and describes the mechanics and economics of producing inert gases right at the industrial user's plant. *C. M. Kemp Mfg. Co.*

25. Generators
4-page leaflet describes construction details of high-speed, revolving-field type synchronous A.C. generators, for coupled or belted service. *Columbia Electric Mfg. Co.*

26. Grinders
New 6-page bulletin on AB Surfacers and grinders, including a description of new wet power grinders and duo-belt wet surfacers, and illustrations of complete line of equipment for metallurgical laboratory. *Buehler Ltd.*

27. Heat Exchangers
Illustrations and pertinent data on complete line of redesigned "BCF" exchangers are presented in colorful new bulletin. Cut-away views of construction, and line drawings showing sizes, weights and a brief text on various applications. *Ross Heater & Mfg. Co.*

28. Heat Treating
New bulletin now available on Series T Ipsen Automatic Heat Treating Unit for lower costs and efficient operation. *Ipsen Industries, Inc.*

29. Heat Treating
"Tips and Trends", new house organ of Ajax Electric, is devoted exclusively to experiences in the field of salt bath heat treating and processes. *Ajax Electric Co.*

30. Heat Treating
Handy, vest-pocket data book has 72 pages of charts, tables, diagrams and factual data on late steel specifications, heat treatments, etc. *Sunbeam Industrial Furnace Div.*

31. Heating Elements
Non-metallic heating elements assure accurately controlled temperatures to provide uniform heat treatment. Informative literature is available. *Globar Div., Carborundum Co.*

32. Heating, Induction
Electronic induction heating discussed in bulletin 1410. *Electronics Div., Lindberg Engineering Co.*

33. Heating Units
The right answer for almost any heating problem can be found in these new heating units, made in immersion or straight rod model and recommended for safe, economical temperature control. *Yale & Towne Mfg. Co.*

34. High Temperature Testing of Metals
For precise hi-temperature testing send for illustrated technical folder on Marshall equipment. *L. H. Marshall Co.*

35. High Temperature Tube Steels
New edition of Technical Bulletin 6-E contains 147 pages of up-to-date metallurgical and application data on steel tubing for high pressure, high temperature services. *Babcock & Wilcox Tube Co.*

36. Induction Heating
Announcing a new comprehensive 48-page brochure on induction heating. First part devoted to general principles involved. Contents sectionalized so that all brazing applications are in one folder, all heating for forging applications in another and so forth. Write for all or any of these sections. *Ohio Crankshaft Co.*

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WHAT'S NEW

IN MANUFACTURERS' LITERATURE

37. Industrial Chemicals

New book "Industrial Chemicals" contains alphabetical listing of industrial chemicals available and diversity of manufactured items. *Harshaw Chemical Co.*

38. Instruments, Selection

Revised bulletin 98170 answers numerous requests for information on "Taylor Guide to Correct Instrument Selection". *Taylor Instrument Co.*

39. Lab Furnaces

New pot furnaces for laboratory and research use are described in Bulletin HD-635 and HD-546. *Hevi Duty Electric Co.*

40. Lab Shaker

New laboratory shakers provide: (1) the right carrier for the individual container to be shaken, and (2) a variety of speeds to produce the agitation rate required. Described in 4-page leaflet. *Eberbach & Son Co.*

41. Lubrication, High Temperature

Lubrication of equipment operating at high temperatures with "dag" colloidal graphite dispersions discussed in literature. *Acheson Colloids Corp.*

42. Microcasting

"New Horizons with Microcasting" 10-page booklet containing complete information on precision investment casting technique, better methods of microcasting and illustrations of various parts manufactured. *Austenal Laboratories, Inc.*

43. Microscopes, Stereoscopic

Complete new line of 15 models in stereoscopic wide field microscopes described and fully illustrated in bulletin D-16, furnished on request. *Bausch & Lomb Optical Co.*

44. Mounting Press

New "Precision" semi-automatic specimen mounting press which simplifies specimen mounting presented in Metallurgical catalog No. 850-P. *Precision Scientific Co.*

45. Oil Standby

8-page bulletin gives specifications and engineering details of oil standby equipment to avert plant shutdowns by having two fuels available. Inserted in gas burners, equipment provides quick change-over gas-to-oil and oil-to-gas. *Surface Combustion Corp.*

46. Open Hearth Flues

Building of open hearth flues with refractory concrete and a manual on general use of this concrete, provided in booklet form. *Lumnite Div., Universal Atlas Cement Co.*

47. Photomicrography

Two new pamphlets listing selected references on photomicrography and electron micrography are available. *Eastman Kodak Co.*

48. Plating

Smooth plating and advantages of Unichrome Copper discussed in informative bulletin. *United Chromium, Inc.*

49. Plating, Copper

New folders on bright copper plating process with data sheets and operating information, and also new compounds for metal cleaning and finishing. *MacDermid, Inc.*

50. Polishing and Buffing

Packer-Matic with an abrasive belt head for small lot polishing and buffing jobs described in bulletin 17. *Packer Machine Co.*

51. Potentiometer, Portable

This potentiometer, available in a selection of ranges up to 1.6 volts, is described with other potentiometers in bulletin 270 and 270A. *Rubicon Co.*

52. Potentiometers

Catalog 15-13 describes new instruments and systems using potentiometers, as well as many schematic diagrams, illustrative tables of various control forms, and other data helpful in proper instrumentation. Copy will be sent on request. *Brown Instrument Co.*

53. Powder Metal Parts

264-page catalog gives full details on Gramix, a product of powder metallurgy, including typical parts, applications, how made, design, characteristics. *United States Graphite Co.*

54. Presses, Powder

32-page catalog describes and illustrates presses for automatically forming compacts from powdered materials under high compressing pressures. *Kux Machine Co.*

55. Presses, Powder Metal

New leaflet describes heavy-duty powder metal presses. Send your samples for free analysis and detailed data or catalogs. *Stokes Machine Co.*

56. Pyrolance

New bulletin includes photos, complete descriptions and prices of the Pyrolance for temperature readings of molten metal in nonferrous foundries. *Illinois Testing Laboratories, Inc.*

57. Quench Temperatures

Better control of quenching temperatures with Aero heat exchangers discussed in bulletin 96-MP. *Niagara Blower Co.*

58. Quenching

Hardness without distortion or cracking thru use of Super-Quench oil discussed in brochure. *Gulf Oil Corp.*

59. Refractory Bricks

16-page booklet discusses refractory brick and features Alundum brick for furnace walls. *Norton Co.*

60. Regulators, Atmospheric

Capacities, prices and dimensions of the new series 18 soft-seat atmospheric regulator for low pressure gas in industrial heating are given in bulletin. *North American Mfg. Co.*

61. Sawing, Contour

"They Cover the Field" is the title of a new 8-page color illustrated catalog on complete line of high speed contour sawing machines. Photos show technique used in cutting aluminum castings, flatiron castings, curved wood drawers, etc. *The DoAll Co.*

62. Sawing, Etc.

16-page booklet profusely illustrates the circular sawing of metals, and new automatic machine for circular sawing, double end-chamfering, drilling, threading, centering and hollow milling. *Motch & Merryweather Machinery Co.*

63. Shapes, Extruded Alloys

"Titan Extruded Shapes" illustrates brass and bronze extrusions. Also lists chemical composition and physical properties of nine alloys used for extruded shapes, including standard half rounds and half ovals. *Titan Metal Mfg. Co.*

64. Solder

If you want basic information about the right solder for almost every job, write for Bulletin No. 87, "Some Properties of Soft Solders". *Federated Metals Div.*

65. Spray Booths

New portfolio on paint spray booth maintenance, containing vital and important articles such as, "Operating Suggestions for Water Curtain Spray Booths", "Conditioning the Water for Wet Spray Booths", and "To Operate and Clean Wet Spray Booths". *Dubois Co.*

66. Stabilizer, Voltage

New model hermetically-sealed stabilizer for both line and frequency regulation. Designed for maximum resistance to shock and corrosion. Described in bulletin furnished on request. *Raytheon Mfg. Co.*

67. Steel, Alloy

Hi-Steel, a low-alloy steel with nearly twice the yield strength of ordinary structural steel, described in bulletin 11. *Inland Steel Co.*

68. Steel, Cold Finished

New technical booklet on cold finished Jalcase steel just published. Contains complete information on the physical properties of this free-machining open hearth steel, used extensively in production of machined parts. Generously illustrated with photographs and charts. *Jones & Laughlin Steel Corp.*

69. Steel Dies, Gages

Many advantages of Graph-Mo steels in giving superior accuracy and longer service for dies and gages are described in illustrated, fact-packed booklet. *Steel and Tube Div., Timken Roller Bearing Co.*

70. Steel, Stainless

38-page booklet gives up-to-the-minute facts and figures on use of stainless steels in the chemical processing, acid manufacture, and general processing fields. *Allegheny Ludlum Steel Corp.*

71. Testing

Model "L" tester, a precision instrument of seven different ranges is described in 4-page bulletin, giving valuable and practical information on virtually any type of material from fabrics to strong metals. *W. C. Dillon & Co.*

72. Testing

Bulletin 291 features simple cartoon sketches showing effect of dynamic and cyclic stresses on many machine parts, and emphasizing the need for testing designs and materials together by fatigue methods. *Baldwin Locomotive Works.*

73. Welding, Arc

Catalog contains latest information on induction heating for preheating, normalizing and welding. *Electric Arc, Inc.*

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HYDROGEN FROM CORROSION*

(Continued from p. 88)
parts fail because of embrittlement. High temperature, moisture, and the release of hydrogen by corrosion furnish atomic hydrogen to the metal surface.

Blister formation is ascribed to the different diffusion characteristics of atomic and molecular hydrogen. Atomic hydrogen diffuses through the steel and combines to form molecular hydrogen at voids or discontinuities in the metal. The molecular hydrogen is trapped and builds up pressure.

Blistering, embrittlement and failures in refining and processing equipment can be minimized through the use of materials more corrosion resistant than ordinary steel, the use of protective coatings, improved homogeneity of the steel and by controlling the environment, as by removing hydrogen sulphide. The use of a carbon steel inner shell is suggested also. This shell would be subject to blistering and embrittlement but the outer shell, which furnishes the structural strength, would not because it would not be in contact with the corrodent. Holes drilled in the outer shell would permit the hydrogen to escape.

In addition to hydrogen sulphide, the elements sulphur, arsenic, selenium, tellurium, antimony and phosphorus in the process liquor promote damage by hydrogen. Perhaps effective inhibitors will be found or developed.

DESULPHURIZATION*

SLAG MIXTURES normally used in openhearth and arc furnaces are often ineffective when applied in high-frequency induction furnaces. The temperature of the slag is too low for rapid action and it has a highly corrosive effect on the lining of the crucible. The use of sodium carbonate, so effective in desulphurizing foundry iron, leads to poor results because of the volatilization of sodium at the temperatures of

(Continued on p. 92)

*Abstracted from "Contributions to the Problem of Desulphurization in a High-Frequency Furnace", by H. Haemers, *Revue de Métallurgie*, 1948, p. 211-214.

DESULPHURIZATION

(Continued from p. 90)

molten steel. The author's experiments with mixtures of 200 g. neutral sodium silicates with 50 g. sodium carbonate and 10 g. powdered manganese per 10 kg. of metal, using double, triple and quadruple slagging at temperatures between 2840 and 2900° F., permitted the sulphur content to be reduced from 0.09 to about 0.025% in from 50 to 100 min., which is too slow.

The author mentions the work of T. B. Winkler and J. Chipman, who raised the temperature of the slag by heating it with an overhead arc in a vacuum, and remarks, quite justly, that the method could not be conveniently applied industrially. He himself heated his slags by immersing graphite electrodes into them and sending through some 100 to 150 amp. at 50 volts.

The author believes that he solved the problem by forming a slag of calcined dolomite with 20% calcium fluoride. Scrap metal with 0.09% S was reduced to 0.034% S in 10 min. and to 0.007% in 25 min. The carbon content rose by 0.025% on the average.

His furnace of 20-kg. capacity was lined with magnesia wetted with sea water and carrying 5% silica. He found this lining mechanically strong and virtually immune to the action of the slag used.

EFFECTS OF WETTING ON STRENGTH*

THE INVESTIGATION reported was initiated in 1931 when key pins in the shaftings of some generators in a Swedish power station failed for no obvious reason. There was no corrosive medium, and no excessive stresses could develop.

It was remembered, in connection with these failures, that Smekal had found glass to fail under rather low stresses (in bending) when wetted with certain liquids, and also that glass could be cut without cracking extensively when under water. For that reason Benedicks undertook to study the effects of

(Continued on p. 94)

*Abstracted from "The Effects of Wetting on Strength", by C. Benedicks, *Revue de Métallurgie*, 1948, p. 9-18.

THIS PAGE FOR IMAGINEERS

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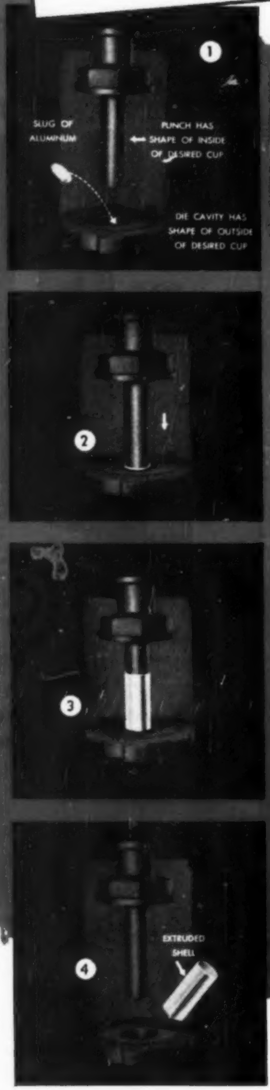

In a fraction of a second, a slug of aluminum becomes a semifinished part, in the Alcoa Impact Extrusion Presses. Here, formed in one swift stroke, can be a housing, or shell, or body, or cylinder; strong, stiff, ready for final assembly operations. A part with sides and bottom integral; as large as 5″ in diameter, 16″ long!

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EFFECTS OF WETTING ON STRENGTH

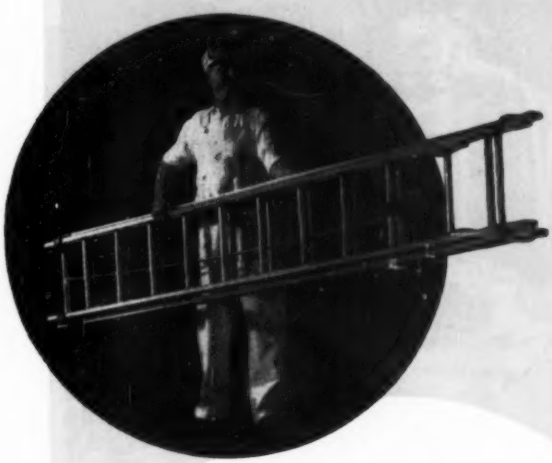
(Continued from p. 92)
wetting on steel. In order not to blur the results by plasticity effects, the tests were made on thin (1 to 2 mm.) strips of water quenched 1.2 and 0.7% C steels and on strips of commercial 13% Cr steel. The chromium steel was tested for endurance when wetted with water only, and it was found that the endurance limit decreased by 40 to 60%. The other two steels were tested in bending with the Chevenard microtesting apparatus. As many as 20 samples were tested for each steel, and the results were rather regular, showing that there are numerous liquids which definitely decrease the resistance to bending without producing any corrosive effect and that there are others which just as definitely increase the resistance. Water and alcohols belong to the first group; oils, petroleum, kerosene, benzene and aqueous solutions of NaOH, to the second group.

The author offered the following theoretical explanation: If a liquid stays on the surface of the metal without descending into the tiny fissures (pre-existing or forming during the test) it causes the interatomic forces to be partly deflected from the metal toward the liquid and so decreases the resistance of the surface layers. If, however, the liquid fills up such fissures it acts as a sort of glue, thus adding to the resistance that might disappear if the atomic distance were increased beyond 1.28 Å for iron and 1.74 Å for lead. (These distances seem to be the atomic radii of iron and lead.)

Reviewer's Remarks: It seems to this reviewer that Professor Benedicks' theory cannot be accepted. A molecule of alcohol, water, or oil is larger in every direction than the mentioned atomic radii. It is most unlikely that any of these liquids could penetrate into a fissure 1000 Å wide. Liquid mercury will not descend into a tube less than 0.1 mm. in diameter and molten platinum will not leak into a crack 1 mm. wide and 20 mm.

(Continued on p. 96)

A REVEALING NEW BOOK—Here's the inside story on how manufacturers of a wide range of products have found that it pays to use magnesium. It's a book of actual case studies of successful magnesium applications—a book that will be of direct interest to you.



How Magnesium Pays

IN MANUALLY HANDLED EQUIPMENT

PROBLEM:
Reducing weight meant reducing handling costs of this ladder. That's why the manufacturer considered substituting another material for wood. He found wood unnecessarily heavy, and subject to warping, rotting and splintering.

SOLUTION: Magnesium extrusions are welded, riveted or bolted together to make a variety of sizes—ranging from stepladders to 24′, 32′ and 36′ extension ladders. Magnesium first provides lightness. The 24′ extension ladder in wood weighs 63 pounds—in magnesium only 28 pounds. Second, by eliminating rotting, warping and splintering, greater durability has been achieved in the magnesium type. Since the properties of magnesium are more uniform than those of wood, more efficiently designed sections can be used.

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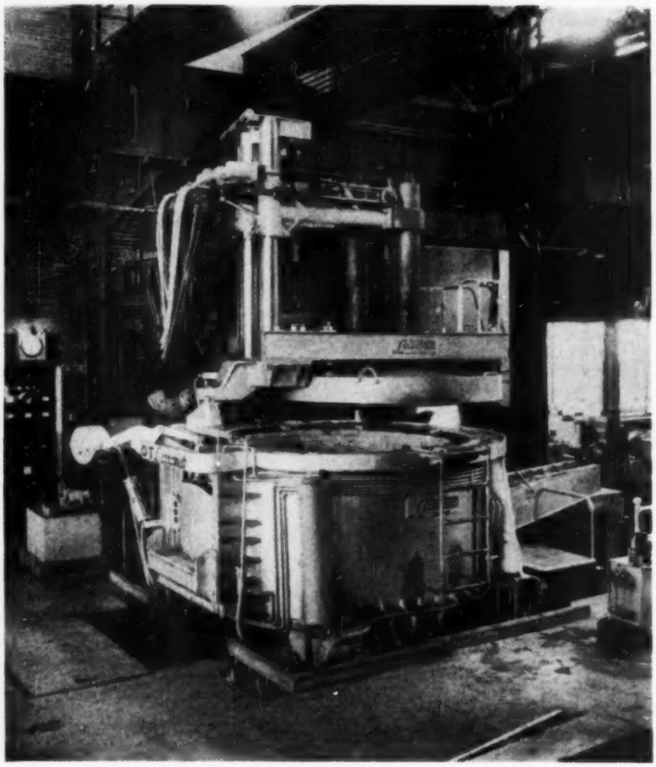

EFFECTS OF WETTING ON STRENGTH

(Continued from p. 94)

long in the bottom of a furnace lined with blocks of calcined limestone. The design of certain piston-operated vacuum pumps has been based on the fact that oil or mercury will not penetrate narrow clearances.

The negative action of water on the strength of steel, glass and mica, as well as the positive action of oils and hydrocarbons, must remain at present an unsolved, though rather interesting, problem. Ordinary tensile tests should be made in order to see whether those effects remain quantitatively noticeable for ordinary steels, not merely the highly stressed, strictly martensitic thin strips tested in bending, where the resistance of the surface layer is the main factor in the observable strength of the samples. The key pins in the shafts that failed were scarcely so high in carbon or so martensitic in structure. — M. G. C.

Fe-Cr-Mn ALLOYS*

THIS was an experimental study of the 0.6 and 1.4% Mn sections of the iron-chromium-manganese system up to 22% Cr. The alloys were made in an aluminum oxide crucible in a high-frequency induction furnace from Armco iron, electrolytic chromium and electrolytic manganese.

Dilatometric analyses were made on a Chevenard dilatometer for the annealed alloys, employing heating and cooling rates of 200° C. (360° F.) per hr. within the range of temperature from 200 to 900° C. (392 to 1652° F.). The alpha-to-gamma transformation failed to occur in 0.6% Mn alloys containing 14.56% Cr or more, and in the 1.4% Mn alloys this transformation disappeared beginning with the 15.53% Cr specimen. The minimum point of the gamma loop was found to be at about 8% Cr in both the 0.6 and 1.4% Mn alloys.

(Continued on p. 98)

*Abstracted from "The Influence of Manganese on the Polymorphic Transition in Iron-Chromium Alloys", by A. T. Grigor'ev and D. L. Kudryavtsev, *Bulletin* of the Academy of Sciences (U.S.S.R.), Chemical Science Section, No. 4, 1947, p. 329-335.

Fe-Cr-Mn ALLOYS

(Continued from p. 96)

The temperature of the transformation that occurs on cooling (gamma to alpha) falls continuously in proportion to the chromium content. This is the behavior characteristic of an "open gamma loop". The alloys in this group were later shown to be in the martensitic condition. On the other hand, the transformation on heating (alpha to gamma) proceeds like that characteristic of a "closed gamma loop". The temperature hysteresis evidently increases with increasing chromium content and reaches 400° C. (720° F.) at 11.27% Cr.

Hardness tests were made on specimens homogenized at 1200° C. (2192° F.), annealed for 15 days at the temperature in question, and then quenched. The hardness and dilatometry data show that the effect of increasing manganese content on the gamma loop in iron-chromium alloys is to widen the two-phase region and to shift the loop to lower temperatures and higher concentrations. Microscopic studies supported these conclusions.

The electrical resistance of the annealed alloys was determined at room temperature. A minimum was observed at 5.5% Cr in the 0.6% Mn alloys, and at 17% Cr in the 1.4% Mn alloys. These data failed to correlate with the hardness results, and the discrepancy was attributed to nonequilibrium conditions.

Fe-C-Be ALLOYS*

STARTING WITH molten white iron of 3.65% C, 0.25% Si and 0.25% Mn, adding to it Armco iron in order to reduce the carbon content or electrode carbon in order to raise it, the author examined the effects of up to 3.88% Be on cast iron cast in dry sand molds. Seven of his alloys had about 3.2% C, four had about 4.4% C; two alloys with 3.4 and 3.7% C were used, apparently, as blanks. The resulting alloys were examined as cast, as oil quenched from 1740° F. and as

(Continued on p. 100)

*Abstracted from "The Constitution and Properties of Iron-Carbon-Beryllium Alloys With More Than 3% Carbon", by M. Ballay, *Revue de Métallurgie*, 1948, p. 231-238.

The gains made by this company* in soldering kitchen utensil assemblies are profitable from any angle.

They saved $6,384 every 28 working days. They slashed power costs heavily. They cut rejects. They reduced polishing time sharply. And they stepped up production from one utensil per man-hour to 600 per man-hour!

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Fe-C-Be ALLOYS

(Continued from p. 98)
nitrided in the ordinary manner.

The micrographs are not convincing; the highest magnification is only 350×. The tabulated results of the micrographic investigations are not quite concordant either. It seems that the author established in a general manner the graphitization effects of small additions of beryllium (up to 1% perhaps), the formation of a double cementite (carbide of iron plus carbide of beryllium) up to about 2% Be, and the increasing preponderance of a separate beryllium carbide above 2% Be.

The author's hardness tests seem to prove that increasing amounts of beryllium increase the capacity of the metal to form martensite on quenching, which effect can offset to a great extent the softening caused by the formation of graphite. They show also that the white irons containing beryllium can be nitrided to a considerable extent, although beryllium cannot compete with aluminum either in price or effect.

REVIEWER'S CONTRIBUTION: In connection with the above abstract it might be interesting to mention some work done in 1942 on beryllium steels, but never published because it was neither completed nor checked by a complete chemical analysis. Five series of steels were prepared carrying no alloying element, 2% Mn, 2% Ni, 2% Cr, and 5% W, respectively. The carbon contents were (nominally) from 0.3 to 0.6 and 0.9%, and the beryllium contents from 0.25 to 0.5 and 1.0%. It was hoped that the beryllium added might produce a secondary hardening both during tempering of the quenched steels and during nitriding, thus counteracting the softening caused by the destruction of martensite. But the nitriding was never done and no positive effects were observed on tempering.

The only satisfaction derived from that work consisted in observing the beautiful formations of martensite, even in the nickel steels with a nominal content of 0.5% Be, and some extremely interesting structures with 1.0% Be. However, none of the structures were investigated as they should have been, and only one useful conclusion can be drawn: Beryllium is of no industrial value whatsover in carbon and low-alloy steels. Apparently the same is true for beryllium-bearing white irons. — M. G. C.

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The special, closed-bottom Inconel retort is used for chromising powdered sintered metal products at 1750°F. Gasketed cover bolts in place . . . provides feed and exhaust lines. Work is placed in baskets shown, and assembly is used with L & N Homocarb furnace.

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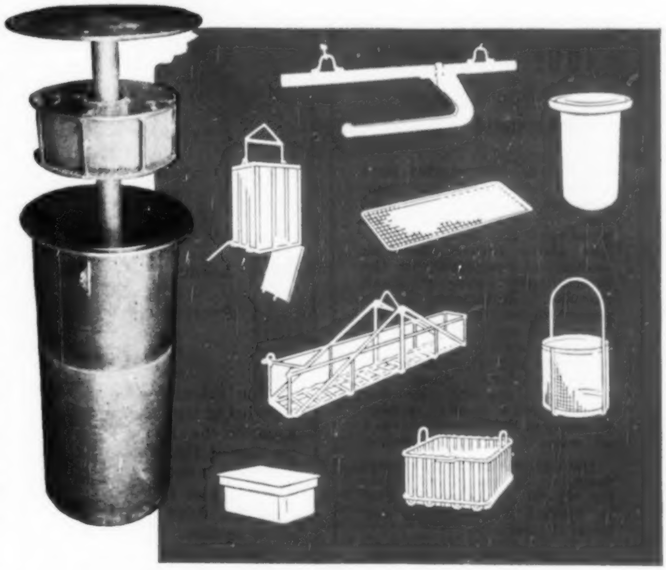

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MOLTEN PIG IRON*

THIS INVESTIGATION was made in order to determine the velocities in the cross section of a stream of molten pig iron.

The principal experimental difficulty was in devising a reliable apparatus for measuring the velocity of white-hot metal. A Pitot tube was known to be unsuitable as a result of freezing of the metal in the tube. Therefore a new device was designed and built, based on other principles for measuring velocities. The device had as its essential part a quartz tube through which air was caused to flow. When this tube was placed in the stream of metal parallel to the direction of flow and with the stream of air opposite in direction to the flow of metal, any change in the velocity of the flow of metal caused a change in the velocity of the stream of air. The velocity v of the stream of molten metal was calculated from the experimental data, using the formula:

$$v=\left(2g\left\{\frac{p}{\gamma_1}-\left[\frac{\gamma}{\gamma_1}h+P\right]\right\}\right)^{1/2}$$

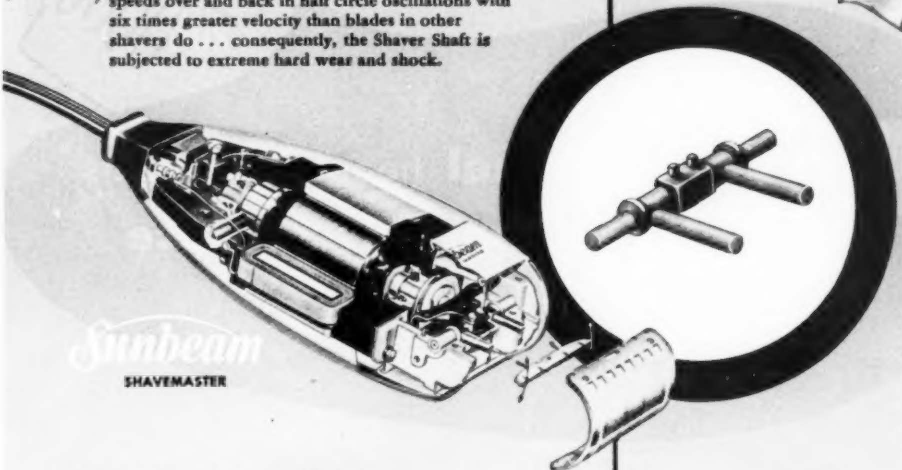
where g = acceleration due to gravity
p = pressure of air in the supply cylinder
γ = specific gravity of the water in the differential manometer
γ_1 = specific gravity of the liquid metal
h = difference of level in the differential manometer
P = static pressure of liquid metal above the quartz tube at the discharge end

The velocity was measured for iron being tapped from a blast furnace in the Kosogorski Works in the city of Tula. The iron contained 3.43% Si, 1.03% Mn, and 0.012% S. The channel in which the molten pig iron flowed had a triangular cross section. Measurements made at various points of the stream of metal showed very nearly the form of velocity curve found for ordinary turbulent flow; the results did not show anything unexpected. That is, the mechanism of flow of molten metal is the same as the flow of normal liquids.

*Abstracted from "Experimental Investigation of the Flow of Molten Metal in an Open Channel", by E. Z. Rabinovich, *Reports* of the Academy of Sciences (U.S.S.R.), Vol. 54, No. 3, 1946, p. 201-203.

here's how Microcastings make possible faster, smoother shaves

The MICROCAST Shaver Shaft is a vital part in the shaving mechanism of the Sunbeam Shavemaster. This device controls a special cutter which speeds over and back in half circle oscillations with six times greater velocity than blades in other shavers do . . . consequently, the Shaver Shaft is subjected to extreme hard wear and shock.



MICROCASTING SAVES 3 PARTS

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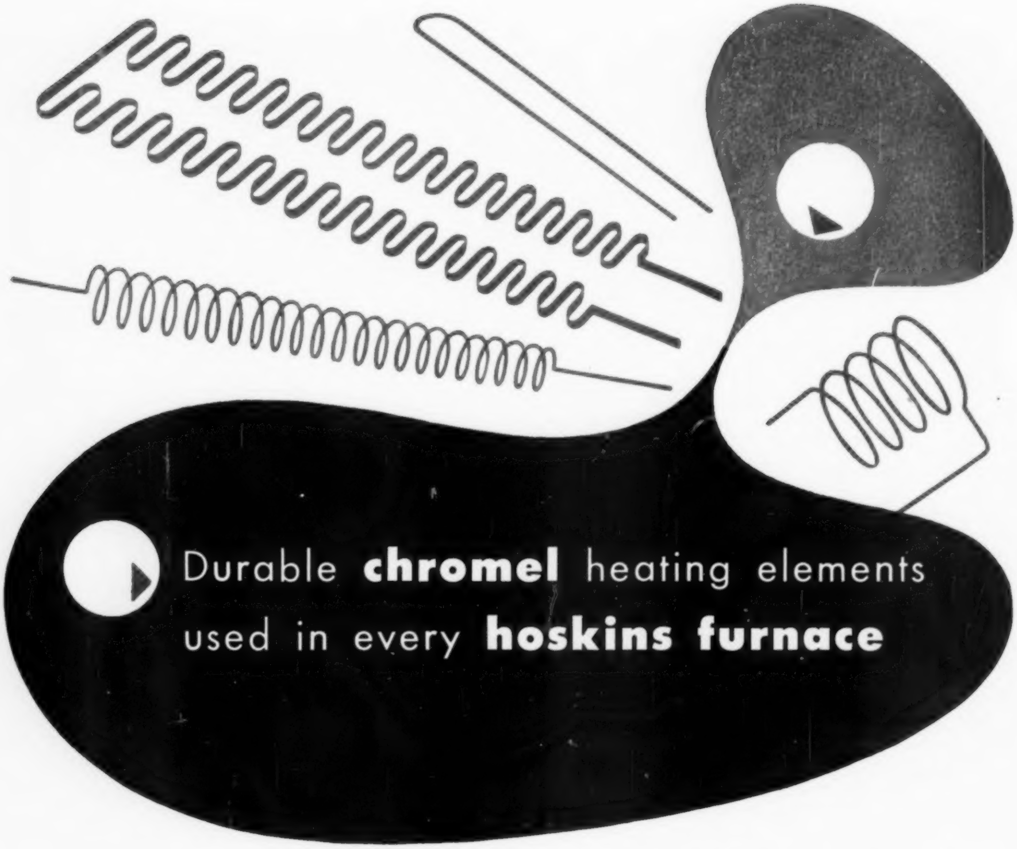

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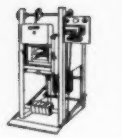
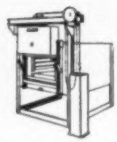
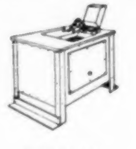


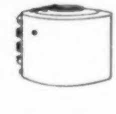
TYPE FR-206, 207, 208
BOX FURNACE



TYPE FR-251
BOX FURNACE



TYPE OR-104
POT FURNACE



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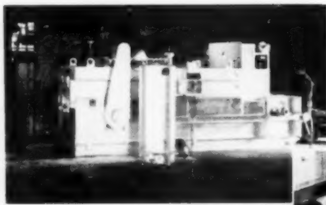

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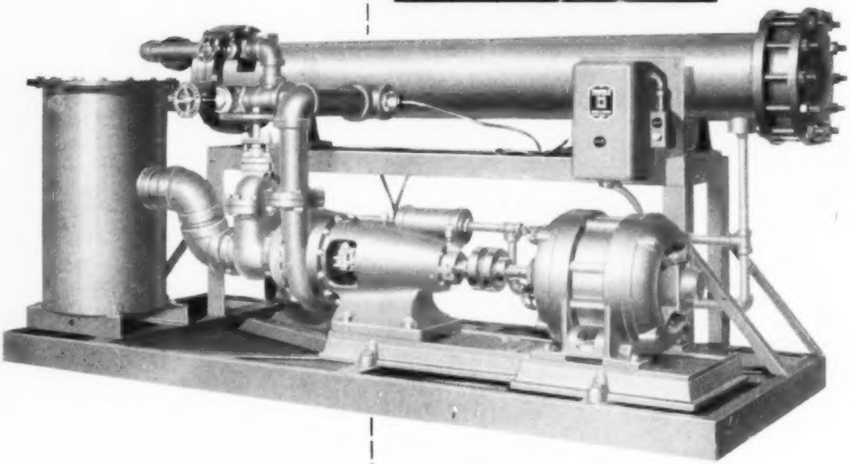

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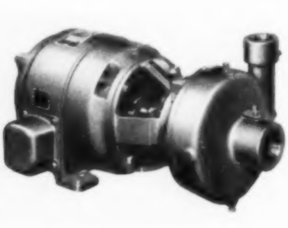

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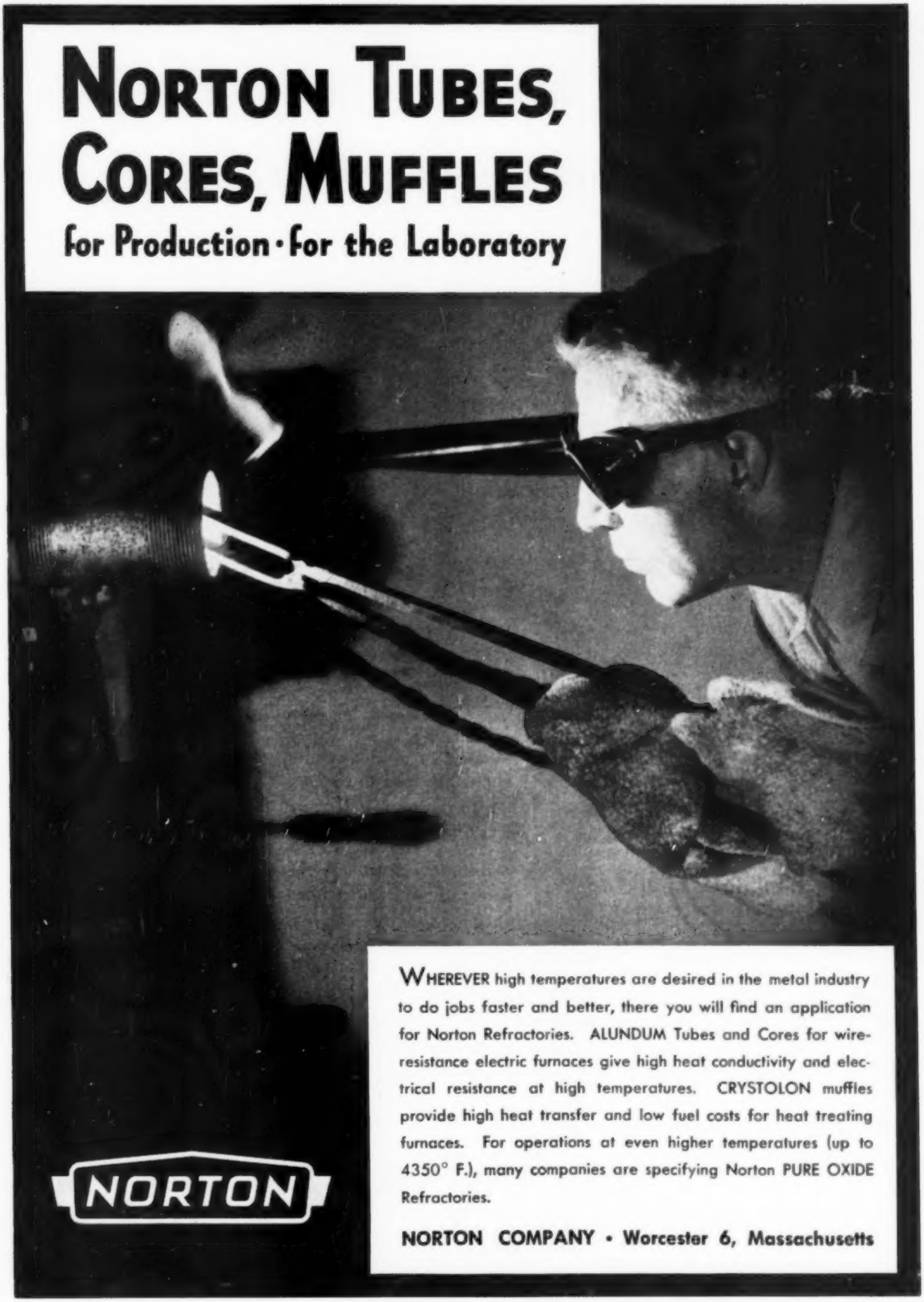
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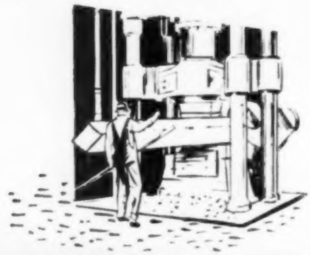
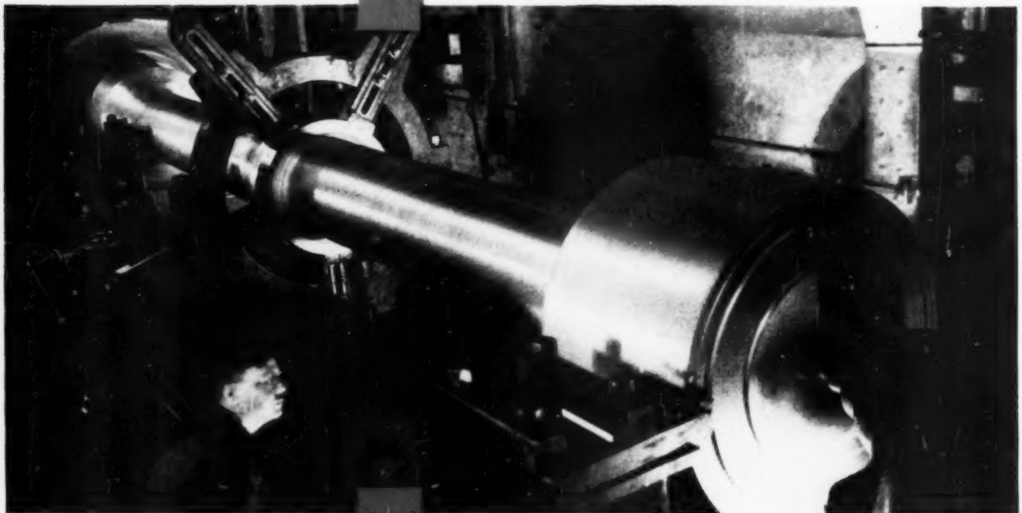
FORGINGS BY FINKL





THIS IS A 46" blooming mill spindle weighing almost 22 tons in the "as forged" condition. It is 24'-10" long and will weigh 18 tons when finished. It was press forged from a 54" ingot weighing 55 tons.

Its highly stressed application in a blooming mill demands strength, stamina, and high fatigue resistance for long life and the utmost in service. Finkl craftsmen build every specification into the job in each stage of its development . . . from research laboratory to finished product.

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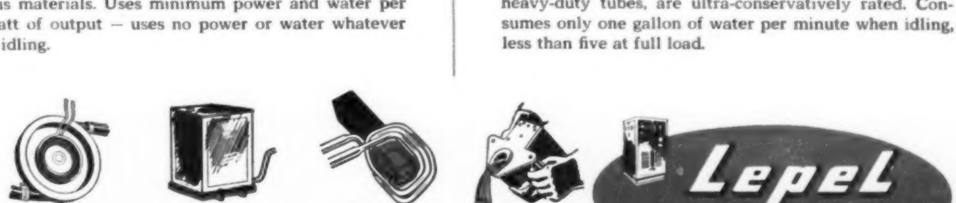

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HOSPHOR BRONZE SPRING WIRE

- **Increases Tensile Strength 10,000 Pounds per Square Inch**
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10 HI-10 New advances in spring design—stronger, longer-lasting springs at *no extra cost*—these are the twin advantages of HI-10 Phosphor Bronze Spring Wire.

10 HI-10 Newest product of Riverside research, HI-10 is warranted to increase tensile strength at least 10,000 pounds per square inch over established standards. It also adds stability and prevents brittleness or any other detrimental effect from aging. Yet, in Grade "A" wire there's no change in standard alloy specifications. HI-10 improves your springs *without* forcing changes in equipment or processing methods—*without* increasing your production costs.

10 HI-10 The special Riverside processing increases the tensile strength of Grade "E" (3% tin) Phosphor Bronze Wire, so that it now possesses the same tensile values presently covered by standard specifications for Grade "A". This lowers your production costs without affecting the quality of your springs. And at the same time, strategic and allocation-controlled tin is conserved.

10 HI-10 Grade "E" HI-10 Phosphor Bronze Wire is highly recommended for formed springs *other than* coil springs. These spring forms are often very difficult to manufacture because of severe bending requirements. Grade "E" HI-10 Phosphor Bronze Wire has excellent ductility and permits twisting and bending to degrees beyond those which can be endured by spring temper Grade "A" Phosphor Bronze Wire. Thus, if you have experienced trouble with the manufacture of such items, Grade "E" HI-10 Phosphor Bronze Wire could be the problem-solver.

10 HI-10 In both Grade "A" and Grade "E", HI-10 Phosphor Bronze Spring Wire is supplied in sizes from .182" diameter down to .0159". Riverside HI-10 is characterized by a somewhat darker, iridescent surface than ordinary phosphor bronze spring wire processed in the conventional way.

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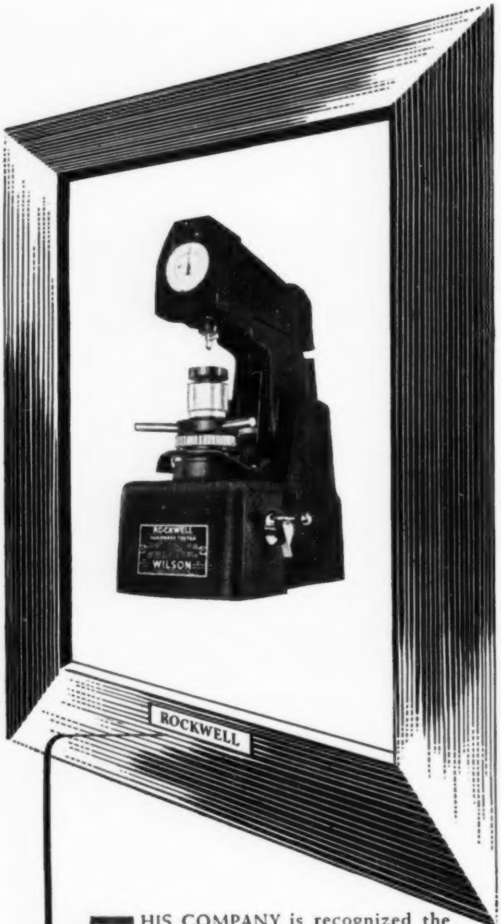

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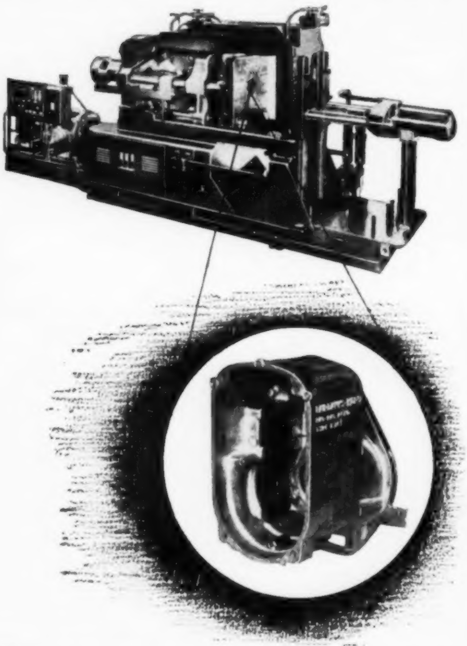

Quality control of all parts assembled into intricate working mechanisms is a must at Fairbanks-Morse in Beloit, Wisconsin. There, plant experts have found that the best means of such control is by die casting parts on Lester-Phoenix equipment in their own plant. Uniform parts and steady, centralized production from Lester-Phoenix die casting machines insures a minimum of assembly problems—and results in maximum efficiency. Your die casting quality and supply problems can be solved by installing Lester-Phoenix equipment in your own plant.

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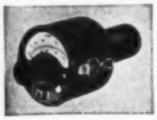

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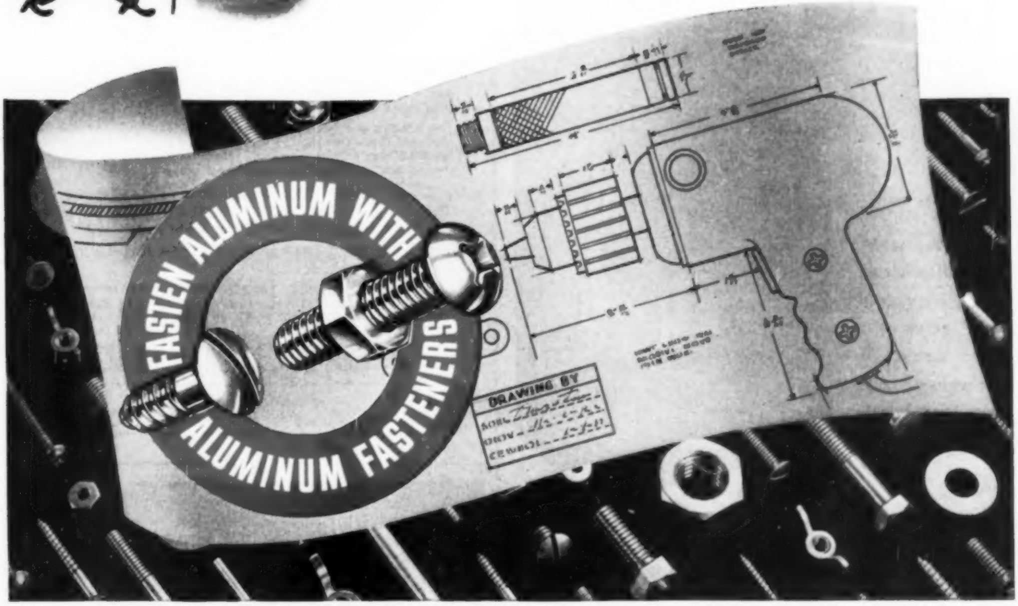

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YOU MUST BE WELL INFORMED!

How up to date

ARE YOU?

Try yourself out on these ten questions. They are all based on current metallurgical developments mentioned in the January issue of Metals Review. Just follow these three steps:

1. Read each question and mark the answer you believe to be correct.

2. Then check the clues given below each question and indicate where the answer can be found in the January issue of Metals Review.

3. Then fill in your name, title and company connection, tear out and mail. That's all.

The names of all who submit ten correct answers by Feb. 15 will be published in the March issue. Get *your* name on Metals Review's Honor Roll of the Well Informed.

NAME ____________________ TITLE ____________

COMPANY ____________________ ASM CHAPTER ____________

Mail to Metals Review 7301 Euclid Avenue CLEVELAND 3, OHIO

1. Drawing of aluminum, steel and brass to depths up to 9 in. in one-stage die operations without excessive workhardening is made possible by:

- (*a*) Heating of the dies
- (*b*) Use of a new type petroleum-base lubricant
- (*c*) Annealing before drawing
- (*d*) A preliminary cold rolling operation

The answer is found in A.S.M. Review of Current Metal Literature, Item No. ——

2. Graphitic nitralloy possesses the properties of nitrided nitralloy, but also has the following added features:

- (*a*) Machinability
- (*b*) Weldability
- (*c*) Ductility
- (*d*) Corrosion resistance

The answer is found in A.S.M. Review of Current Metal Literature, Item No. ——

3. Molten salt bath descaling involves the following principle:

- (*a*) Solution of the surface scale in the salt
- (*b*) A chemical change in the surface scale rendering it readily removable in acid
- (*c*) A physical cleaning action in which the salt replaces the scale and is then readily washed off
- (*d*) An electrolytic action

The answer is found in A.S.M. Review of Current Metal Literature, Item No. ——

4. Factors contributing to weldability of alloy steel plate include:

- (*a*) High hydrogen type flux
- (*b*) High welding speed and heavy deposits
- (*c*) A composition containing ferrite-forming elements in preference to carbide-forming

The answer is found in A.S.M. Review of Current Metal Literature, Item No. ——

5. For optimum heat transmission in strip-coil annealing, the most important factor is:

- (*a*) Conduction through the film
- (*b*) Radiation
- (*c*) Metallic contact

The answer is found in A.S.M. Review of Current Metal Literature, Item No. ——

6. A simple form of accelerated atmospheric corrosion test utilizes:

- (*a*) A warm, humid atmosphere containing SO_2
- (*b*) A hot, dry atmosphere containing H_2S
- (*c*) A room-temperature atmosphere saturated with nitric acid vapor

The answer is found in A.S.M. Review of Current Metal Literature, Item No. ——

7. Porous alloys of high permeability and strength have been developed for "sweat cooling" of jet engine components. The method involves:

- (*a*) A combination of thermosetting resins and metal powder
- (*b*) Mixing the powder with ammonium carbonate, which gasifies on sintering
- (*c*) Hot pressing using a plastic to improve flowability

The answer is found in the news and feature section, January Metals Review, page ——

8. The cause of toughness in quenched steels when tempered at 400° F. or below, and also the cause of brittleness when the same steels are tempered at 500° F. and above, is:

- (*a*) Retained austenite
- (*b*) Precipitation of carbides
- (*c*) Holding at temperature for one hour or less
- (*d*) Graphitization

The answer is found in the news and feature section, January Metals Review, page ——

9. Metal-ceramic mixtures are being promoted for jet engine components because of their resistance to high temperature combined with:

- (*a*) Improved workability
- (*b*) Fatigue strength
- (*c*) Resistance to thermal shock
- (*d*) Creep resistance

The answer is found in the news and feature section, January Metals Review, page ——

10. The Western Metal Congress will be held in:

- (*a*) San Francisco in March
- (*b*) Los Angeles in April
- (*c*) Seattle in May
- (*d*) Portland in April

The answer is found in the news and feature section, January Metals Review, page ——.

METAL PROGRESS

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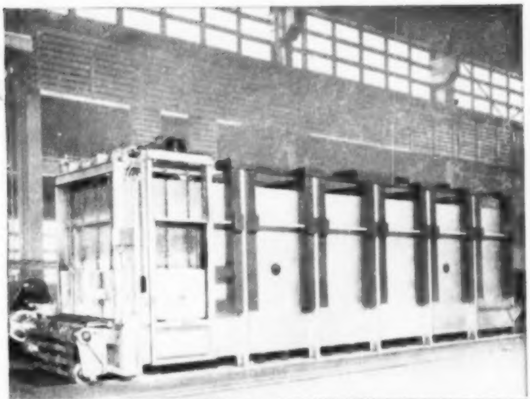

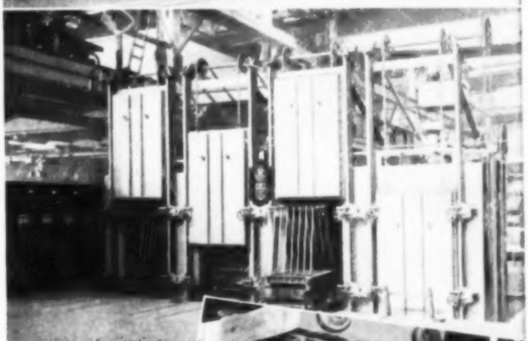

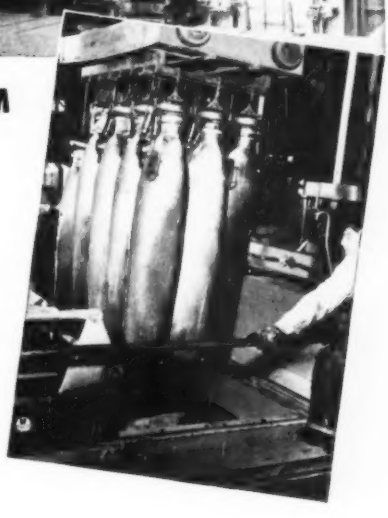

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